WOODWARD

Product Manual 26464
(Revision C, 7/2013)
Original Instructions

E3 Lean Burn Trim System

Application Manual

General Precautions	**Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.** **Practice all plant and safety instructions and precautions.** **Failure to follow instructions can cause personal injury and/or property damage.**

Revisions	**This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, on the *publications page* of the Woodward website:** **www.woodward.com/publications** **The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.**

Proper Use	**Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.**

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- ProAct
- Woodward

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- Modbus (Schneider Automation Inc.)

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Important Definitions

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

WARNING **Overspeed / Overtemperature / Overpressure**	**The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.** **The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.**

WARNING **Personal Protective Equipment**	**The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:** • **Eye Protection** • **Hearing Protection** • **Hard Hat** • **Gloves** • **Safety Boots** • **Respirator** **Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.**

WARNING **Start-up**	**Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.**

WARNING **Automotive Applications**	**On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.**

NOTICE **Battery Charging Device**	**To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.**

Electrostatic Discharge Awareness

NOTICE **Electrostatic Precautions**	**Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:** • **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).** • **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.** • **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.** **To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715*, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.**

Follow these precautions when working with or near the control.

1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Regulatory Compliance

European Compliance for CE Marking

These listings are limited only to those units bearing the CE Marking.

EMC Directive: Declared to 2004/108/EC COUNCIL DIRECTIVE of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and all applicable amendments.

North American Compliance

These listings are limited only to those units bearing the CSA agency identification.

CSA: CSA Certified for Class I, Division 2, Groups A, B, C, & D, T4 at 85 °C Ambient. For use in Canada and the United States.
Certificate 1604047

This product is certified as a component for use in other equipment. The final combination is subject to acceptance by the authority having jurisdiction or local inspection.

Special Conditions for Safe Use

Wiring must be in accordance with North American Class I, Division 2 wiring methods as applicable, and in accordance with the authority having jurisdiction.

Field Wiring must be suitable for at least 95 °C and must be limited to < 30 meters in length.

Connect the system Protective Earth (PE) ground to one of the two available PE connection points on the control housing. Connect the remaining PE connection point on the control housing to PE ground using a low-impedance bond strap or 10 AWG (5.0 mm²) wire no more than 0.5 meters in length.

The Ingress Protection rating of the control depends on the use of proper mating connectors. Refer to Table 3-1 in the Installation section of this manual for information on the proper mating connectors for use with this control.

⚠WARNING

EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.

Substitution of components may impair suitability for Class I, Division or Zone applications.

⚠AVERTISSEMENT

RISQUE D'EXPLOSION—Ne pas raccorder ni débrancher tant que l'installation est sous tension, sauf en cas l'ambiance est décidément non dangereuse.

La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, applications Division ou Zone.

Chapter 1.
General Information

About this Manual

This manual describes how to install, monitor and commission the E3 Lean Burn Trim system. This system can have different configurations. The core functionality is air/fuel ratio trim control using either exhaust oxygen closed loop or generator power feedback. Additional functions are available by adding optional hardware. The following list shows the available functions and the corresponding hardware requirements:

Base System/Base Hardware

Air/fuel ratio control	E3 controller, trim valve & UEGO **OR** kW feedback sensor

Optional Functions/Additional Hardware

Speed/load control	Mixture throttle actuator
Integrated ignition	Smart Coils **OR** IC-920/-922 ignition system
Knock detection	On board for OEMs only
Generator integration	easYgen-3000 family generator controller

System Description

The E3 Lean Burn Trim system is a gas-engine control system that controls speed/load, air/fuel ratio and spark timing/duration, at any engine load and speed condition. Calibration can be fuel specific. It can be applied to mono or multibank engines in a wide range of power outputs, both naturally aspirated and turbo-charged.

The control is easily programmable via Woodward Toolkit using a control-specific HMI. The control covers a wide range of gas compositions, including LPG, pipeline natural gas, landfill gas, and other low heating value gases. Anticipated changes in gas quality during normal operation of the engine are compensated by the control by means of kW feedback or UEGO closed loop.

The fuel metering subsystem consists of a carburetor combined with a fuel trim valve, each appropriately sized for the application.

Integrated ignition featuring Woodward heavy duty 24 volt Smart Coils is available for lower BMEP applications and non-hazardous locations. For higher BMEP applications and those requiring Class I, Division 2 certified ignition, an external IC-920/922 ignition system is available, with standard or shielded capacitive discharge coils, as required. The IC-920/922 ignition controller is integrated with the E3 controller, over a J1939 CAN communication network.

Integrated power management is available using the easYgen-3100/3200 power management controller, which communicates with the E3 controller over a second J1939 CAN communication network.

Nomenclature

A/D	analog-to-digital
A/R	as required
AFR	air to fuel ratio
ATDC	after top dead center
AWG	American Wire Gauge
BARO	barometric pressure
BMEP	brake mean effective pressure
BTDC	before top dead center
c	celerity (the speed of light)
CAN	controller area network, the digital communications link between control modules
ECT	engine coolant temperature
ESD	emergency shutdown
EMI	electromagnetic interference
FMI	failure mode identifier
GQCL	gas quality closed loop, an algorithm using indicated shaft power to infer gas quality for closed loop correction of air/fuel ratio
HMI	human machine interface
I/O	input/output
IAT	inlet air temperature
ITB	integrated throttle body
kbits/s	kilobits/second
kHz	kilohertz
kPa	kilopascals
kW	kilowatt
kWe	kilowatt electric
LPG	liquefied petroleum gas (also referred to as propane)
LSO	low-side output
mA	milliamp
MAP	manifold absolute pressure
MAT	manifold air temperature
Mbit/s	megabits/second
µF	microfarad
MHz	megahertz
mJ	millijoules
MPRD	master power relay driver
MPU	magnetic pickup
ms	milliseconds
N/A	not applicable
N.C.	normally closed
N.O.	normally open
NPT	National Pipe Thread
NTC	negative temperature coefficient
pF	picofarad
PID	proportional-integral-derivative (feedback control parameters)
PN	part number
PWM	pulse width modulated
SAE	Society of Automotive Engineers
SDR	speed derivative ratio
SPN	suspect parameter number
Tau (τ)	time constant (e.g. for a filter)
TDC	top dead center
TMAP	combined manifold temperature and pressure sensor
TPS	throttle position sensor
UEGO	universal exhaust gas oxygen (sensor)
Vdc	voltage of direct current type
vs	versus

Chapter 2.
System Software and HMI Functionality

⚠WARNING	**An unsafe condition could occur with improper use of the HMI tools. Only trained personnel should access the control with these tools.**

NOTICE	**Appropriate security permissions are required to perform these functions.**

This chapter provides detailed information on the system software functions and instructions for their configuration and calibration via the HMI application (Woodward *Toolkit*).

0.0-Navigation Page

The Navigation allows the end user to quickly jump between pages. The pages are sorted by type. The types of pages are "Setup/Configuration", "Generic", "AFR Mode", "Load Control", "I/O", and "Alarm /Shutdown".

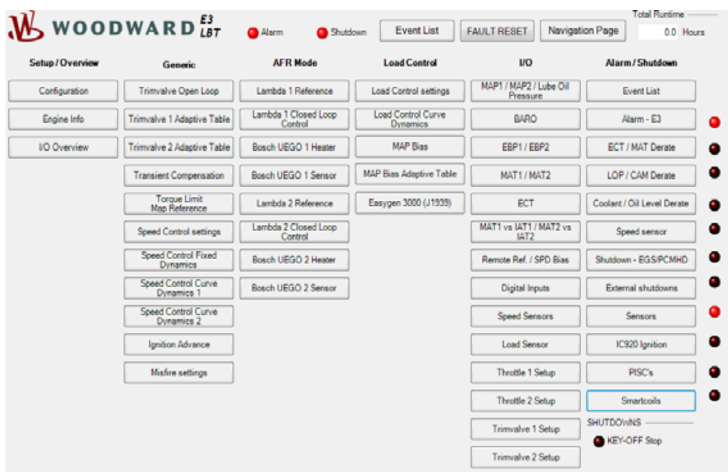


Figure 2-1. 0-0 Navigation Page

The top of each page contains information relative to the system:
Woodward's logo
The name of the specific control: E3 LBT (Lean Burn Trim)
Alarm LED: Red is "True"
Shutdown LED: Red is "True"
Page link to the "Event List"
A momentary reset button. When pressed the control will reset any fault conditions currently latched into the control. In addition the "Fault Reset" button will reset the CAN bus 1 and 2.
Page link to the "Navigation Page"

Mono/Stereo Engine Dashboard

The Mono/Stereo Engine Dashboard is shown on ever page except for the Navigation Page. It contains pertinent current values from the control. The values displayed are dependent on the “Engine Config”. For E3 controls engines with a single fuel supply into the carburetor(s)/venturi(s) and one throttle are considered an “Mono engine” (e.g. Caterpillar 3516). Engines with two separate fuel supplies (regulators, fuel trim valves) feeding two carburetors/venturis and two throttles are considered “Stereo” engines (for example Waukesha 7042GSI).

Mono Engine Dashboard

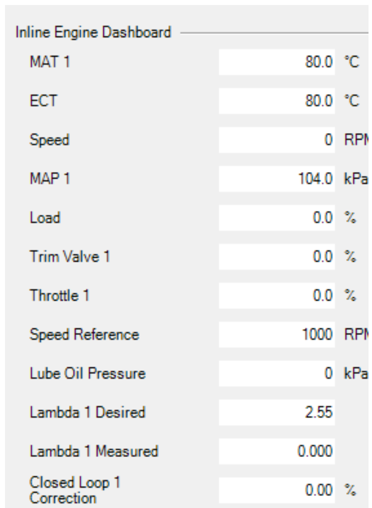


Figure 2-2. Mono Engine Dashboard

MAT1: Temperature the Manifold Air Temperature sensor is reading
ECT: Temperature the Engine Coolant
Speed: Engine’s current revolutions per minute
MAP1: Pressure the Manifold Air Pressure sensor is reading.
Load: Percent load the control is calculating based on MAP reference vs. MAP1, or Load vs. Rated Load
Trim Valve 1: The position demand signal out to the fuel trim valve.
Throttle1: The position demand signal out to the throttle actuator.
Speed Reference: The current speed set point used by the control with all of the biases applied.
Lube Oil Pressure: Pressure the Lube Oil Pressure sensor is reading (if used)
Lambda 1 Desired: Desired Lambda set point
Lambda 1 Measured: Measure Lambda
Closed Loop 1 Correction: Percent the closed loop software is adjusting the Trim valve from the Open loop table settings.

Stereo Engine Dashboard

Figure 2-3. Stereo Engine Dashboard

MAT1: Temperature the first banks Manifold Air Temperature sensor is reading
ECT: Temperature the Engine Coolant
MAT2: Temperature the second banks Manifold Air Temperature sensor is reading

Speed: Engine's current revolutions per minute
MAP2: Pressure the second banks Manifold Air Pressure sensor is reading.
MAP1: Pressure the first banks Manifold Air Pressure sensor is reading.
Load: Percent load the control is calculating based on MAP reference vs. MAP1, or Load vs. Rated Load
Trim Valve 2: The position demand signal out to the second banks fuel trim valve.
Trim Valve 1: The position demand signal out to the first banks fuel trim valve.
Throttle2: The position demand signal out to the second banks throttle actuator.
Throttle1: The position demand signal out to the first banks throttle actuator.
Speed Reference: The current speed set point used by the control with all of the biases applied.
Lube Oil Pressure: Pressure the Lube Oil Pressure sensor is reading (if used)
Lambda 1 Desired: Desired Lambda set point for the first bank
Lambda 2 Desired: Desired Lambda set point for the second bank
Lambda 1 Measured: Measured Lambda for the first bank.
Lambda 2 Measured: Measure Lambda for the second bank.
Closed Loop 1 Correction: Percent the closed loop software is adjusting the first bank's Trim valve 1 command from the Open loop table settings.
Closed Loop 2 Correction: Percent the closed loop software is adjusting the second bank's Trim valve 2 command from the Open loop table settings.
Map Bias: The percent correction from the Throttle1 actuator position demand signal applied to the Throttle2 actuator position demand signal to balance MAP2 to MAP1.

Setup/Overview

This section includes three pages "Configuration", Engine Info", and "I/O Overview".

0.1 Configuration:
This page is where the end user configures the control for their specific application.

SYSTEM SETUP:
Configuration of these parameters is only intended to be performed with the unit stopped.

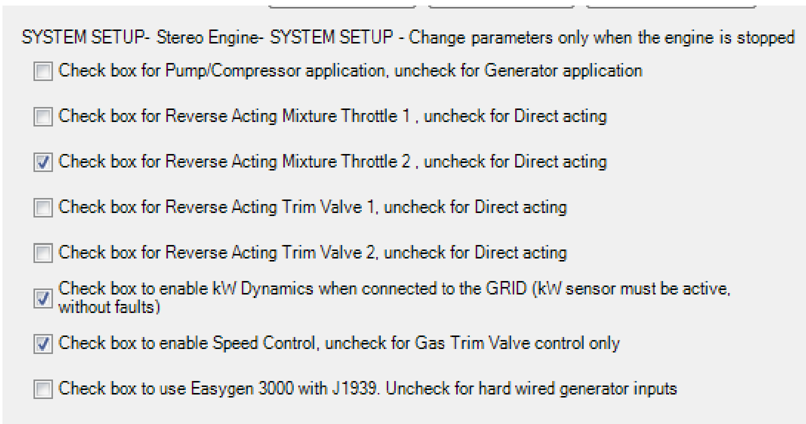


Figure 2-4. Stereo Engine System Setup

The system setup screen for an “Mono Engine” is identical except that the options for Throttle2 and Trim Valve 2 have been removed. In addition GQCL AFR control is only available for “Mono Engine” configurations.

The basic system configuration options are:

Lambda Closed Loop with UEGO sensor or Gas Quality Closed Loop with kW sensor – Unavailable when using Stereo Engine Config- When the system will be used in GQCL this box must be unchecked. When running the system in Lambda Closed Loop this box must be checked.

Pump/Compressor application or Generator application – When the system will be used in generator applications this box must be unchecked. When running the system in pump/compressor (variable speed mechanical drive) applications this box must be checked.

Reverse or Direct Acting Mixture Throttle1/2 – When the system will use a reverse acting throttle this box must be unchecked. With a direct acting throttle this box must be checked.

Reverse or Direct Acting Trim Valve 1/2 – When the system will use a reverse acting trim valve this box must be unchecked. With a direct acting trim valve this box must be checked.

KW Dynamics when connect to the GRID – When there is a kW signal supplied to the E3 controller and the generator will be connected to the grid, and generator load is controlled by the E3 controller, this box need to be checked to activate load control and load dynamics for operation on the grid. When this box is unchecked the Dynamics 2 will be used when connected to the grid.

Speed control or only AFR control – When the mixture throttle is separate from (not controlled by) the E3 system this box must be checked. When the E3 controls speed and AFR in the system this box must be checked.

easYgen-000 with J1939 or hard wired generator analog/discrete inputs – When the system will use an easYgen-3000 with J1939 to receive generator information (measured load, generator and utility breaker, load reference, etc.) this box must be checked. When the E3 controller receives this information via hard wired inputs, this box must be unchecked.

If the E3 Lean Burn Trim system is used in combination with the easYgen-3000, the generator load information can be received over the external J1939 link. In this case, no separate kW sensor is needed.

Ignition Selection:
The options are "Woodward Smart Coils, Woodward IC-92X with J1939 link" (IC-920 or IC-922) or "Third party ignition system".

There are three options for the ignition selection:
0: Woodward SmartCoils (in-line 6) allows usage of Woodward's SmartCoils Inductive system for Mono 6 cylinder engines with a firing order of 1, 5, 3, 6, 2, 4 and angle spacing of 120 degrees between firing event. Installation/application information on Woodward Smart Coils can be found in document 26313 (this document has limited distribution – to receive a copy, please contact Woodward).

1: Woodward IC-920/922 with J1939: Allows communication to the Woodward IC-92X controllers over J1939 on CANbus 1. For IC-920/922, installation and operation information is in document 26263.
2-Third Party Ignition Systems: Selection of this option will turn off all ignition timing biases from the E3.

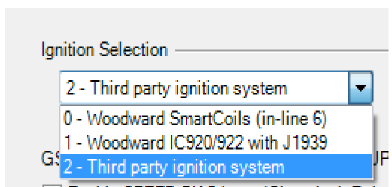


Figure 2-5. Ignition Selection

Engine Config:
For E3 controls engines with a single fuel supply into the carburetor(s)/venturi(s) and one throttle are considered an "Mono engine" (e.g. Caterpillar 3516). Engines with two separate fuel supplies (regulators, fuel trim valves) feeding two carburetors/venturis and two throttles are considered "Stereo" engines (for example Waukesha 7042GSI).

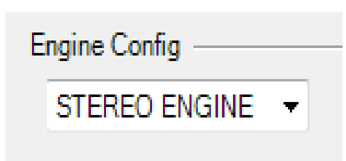


Figure 2-6. Engine Config

Mono Engine: A single fuel supply (regulator and trim valve) feeding carburetor(s)/Venturi(s) and one throttle (e.g. Caterpillar 3516).
Stereo Engine: Engines with two separate fuel supplies (regulators, fuel trim valves) feeding two carburetors/Venturis and two throttles (for example Waukesha 7042GSI).

I/O Setup

The configuration of these parameters allows the user to select which input will be sending signals to the control.

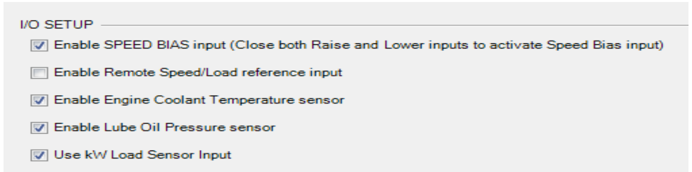


Figure 2-7. I/O Setup

Speed Bias input – Generator Application only – The speed bias input is enabled this by checking this box.

Remote Speed/Load reference input – The remote speed/load reference input is enabled this by checking this box.

Engine Coolant Temperature sensor – The ECT sensor input is enabled by checking this box.

Lube Oil pressure sensor – The LOP sensor input is enabled by checking this box.

kW Load Sensor input – Generator Application only – The kW Load Sensor input is enabled by checking this box.

ACTUATOR SELECT

The control supports four outputs for actuators. Two for throttle control and two more for Fuel Trim Valve control. The demand signals must be unique for each end device. The end devices can be driven with PWM signals, or J1939 CAN. If J1939 CAN is desired for the increased volume of information related to the condition of the actuator the end user can use up to four F-series or ProAct actuator/valves.

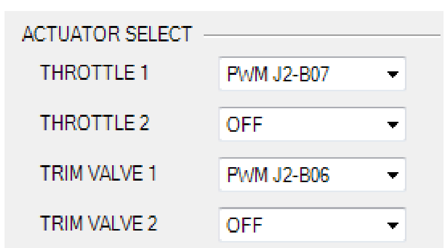


Figure 2-8. ACTUATOR SELECT

Battery Conservation

This output provides a means to turn off or disable electric actuators used by the system. Connect through a relay to control the Actuator power directly. Alternately the relay contacts can be used to switch the RUN ENABLE inputs for the actuators. The relay is energized immediately on control power-up or engine start and resets after the engine has been stopped for a tunable delay time.

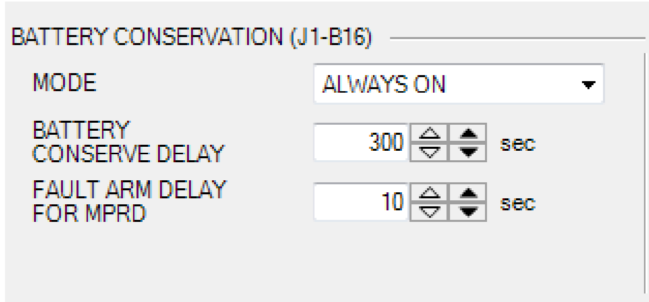


Figure 2-9. BATTERY CONSERVATION

BATTERY CONSERVE DELAY: Time period the BATTERY CONSERVE OUTPUT is on after last engine roll (sec)

MODE : Dropdown select box with possible states: BATTERY CONSERVATION, ALWAYS ON, or ALWAYS OFF. BATTERY CONSERVATION mode sets the relay immediately on engine start and resets after the engine has been stopped for BATTERY CONSERVE DELAY. ALWAYS ON OR ALWAYS OFF modes allow troubleshooting and setup.

0.2- E3 & ENGINE INFO

This page contains information related to the software that is loaded into the control, the engine runtime information, and engine identification information is set.

Software Info
This information can helpful for identifying which software updates from the updates section are available in the controllers software.

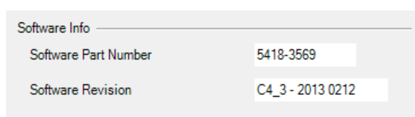


Figure 2-10. Software Info

Software Part Number: The part number of the software loaded into the controller.
Software Revision: The current revision of the software in the control.

Runtime
The information related to how many hours of runtime the unit has accumulated.

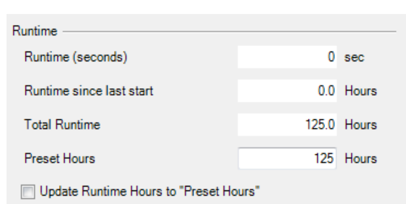


Figure 2-11. Runtime

Preset Hours: User adjustable value to preset the engine hours.
Update Runtime Hours to “Preset”: Check box that updates the current runtime hours to the value entered in the “Preset Hours” box.

Engine Info
The information specific to the unit on which the E3 is installed can be set. Setting this information allows the end user to review settings files in the “Offline Editor”.

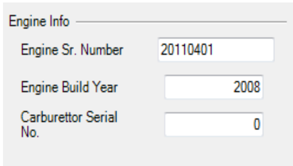


Figure 2-12. Engine Info

Engine Sr. Number: The Serial number of the engine. Note in versions prior to revision “C” this box would only allow numerical inputs.
Engine Build Year: Build Year of the engine.
Carburetor Serial Number: Serial Number of the engine’s carburetor.

0.3- I/O OVERVIEW

This page contains an overview of all the inputs and outputs and their current states.

Discrete Contact Inputs
The E3 control has numerous inputs. The contacts show themselves as “True” when lit “Green”. Typically the status of these inputs is handled with an appropriate external device like a switch or relay that connects J1-A24 to the appropriate pin for the function desired. This arrangement would treat J1-A24 and the functional input pin as “Dry Contacts”. There is no detection of input or wiring failure of these inputs. The Run command input is failsafe. A failed to open input or broken wiring will result in an engine stop command.

Although certain inputs are user configurable for normally open or normally closed operation, it is highly recommended that inputs used for engine or equipment protection (e. g. coolant level, oil level, and external shutdowns) be configured as normally closed, so that a wiring or switch fault will result in a failsafe system shutdown, and will required user override or correction of the fault for engine restart.

NOTICE	**Input and wiring fault detection is not performed on discrete inputs.**

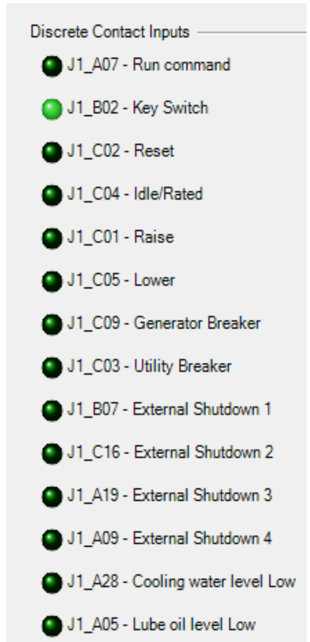


Figure 2-13. Discrete Contact Inputs

Run
Green indicates that the contact is closed. Configuration of this function is described under I/O setup. When this input is active, and engine rotation is detected by the controller, the following will occur:

- gas shutoff valve output is energized (after purge time has expired)
- mixture throttle position command is enabled
- trim valve position command is enabled
- If Smart Coils are used, the spark outputs are enabled.

Key Switch
Green indicates key switched on. There is no user configuration of this function. If a key switch is not used, this input should be powered whenever the system is powered.

Reset
Reset indicates the reset contact is active. This input is used to clear alarms and shutdowns. The input can be configured as a N.O. or N.C. input.

Idle/Rated switch
Green indicates that this contact is active and the speed reference will remain at “Minimum Speed ref/Idle”. The input can be configured as a N.O. or N.C. input.

Raise Speed/Load
Green indicates that this contact is active. The speed or load set point is raised in accordance with the applicable user specified rate (see *Speed Reference* and *Load Control (Grid Mode) Reference* in Chapter 2). The input can be configured as a N.O. or N.C. input.

Lower Speed/Load
Green indicates that this contact is active.
The speed or load set point is lowered in accordance with the applicable user specified rate (see *Speed Reference* and *Load Control (Grid Mode) Reference* in Chapter 2). The input can be configured as a N.O. or N.C. input.

Generator Breaker
Green indicates that the generator breaker is closed.
The input can be configured as a N.O. or N.C. input.

Utility Breaker
Green indicates that the utility breaker is closed. The input can be configured as a N.O. or N.C. input.

External SD
There are four digital inputs used for optional external shutdown. These inputs can be configured as N.O. (normally open) or N.C. (normally closed) input. It is highly recommended that these be used in their default, N.C. configuration only, for fail safe operation.
If the application is for a pump or compressor the shutdowns can be configured as soft shutdown. With a soft shutdown the speed reference will ramp down at the user specified raise/lower speed rate to the user specified minimum speed and then shutdown; the shutdown output will be activated.

Cooling Water Level switch
Cooling water level switch Red indicates that this contact is active signifying that the sensed cooling water level is low.
The input can be configured as a N.O. or N.C. input. It is highly recommended that this input be used in its default, N.C. configuration only, for fail safe operation.

Lube Oil Level switch
Lube Oil level switch Red indicates that this contact is active signifying that the sensed oil level is low. In the default configuration, this input is only monitored when the engine is stopped. This is intended for engines whose oil level may be below the sensor during normal operation. If the lube oil level alarm function is desired when the engine is running as well, please contact Woodward.
The input can be configured as a N.O. or N.C. input. It is highly recommended that this input be used in the N.C. configuration only, for fail-safe operation.

Discrete Outputs
The discrete outputs are all Low side outputs that will sink current when "True" Green.

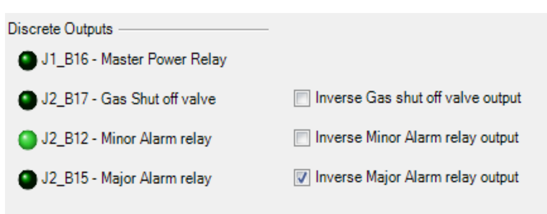


Figure 2-14. Discrete Outputs

Master Power Relay: Based on the Master Power Relay output configuration J1_B16 sinks current.

Gas Shut Off Valve: When the control determines it is safe to turn on fuel J2_B17 sinks current. If this option is used, a redundant automatic gas shutoff valve, that is completely independent of the E3 system is strongly recommended.
Major Relay: When a Shutdown fault occurs J2-B15 sinks current.
Minor Relay: When an Alarm fault occurs J2-B12 sinks current.

Typical application of these outputs to drive a relay is shown in Figure 2-15.

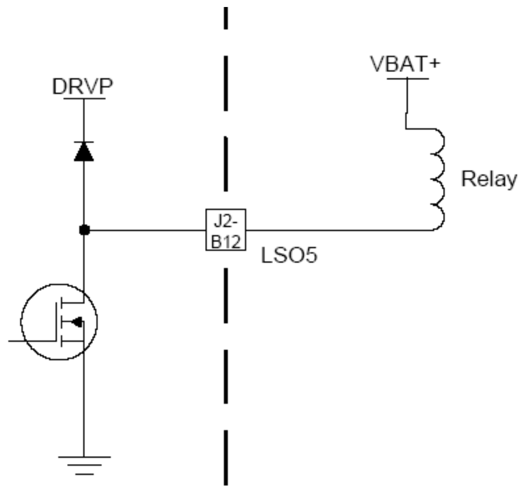


Figure 2-15. LSO Wiring Output Diagram (Alarm Relay shown)

NOTICE

Output and wiring fault detection is not performed on discrete outputs. As no fault detection on the outputs is performed, the Major alarm indication to external devices should not be used as safety devices but on as indication. The external equipment should have its own ESD logic.

Analog Inputs
Analog signal inputs can only be 0.5 to 4.5 Vdc signals. If their grounds are not common to engine ground, they should be isolated with a galvanic isolator.

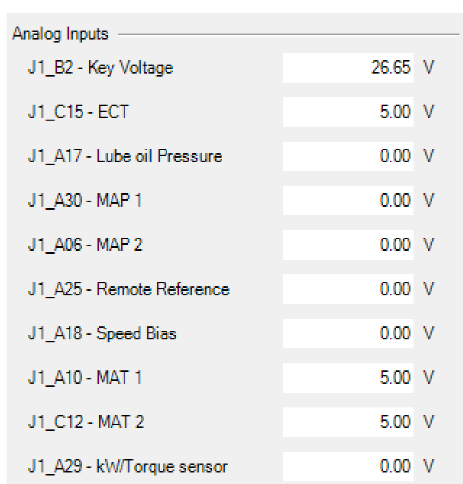


Figure 2-16. Analog Inputs

Throttle Outputs
The % of the command output going out to each actuator.

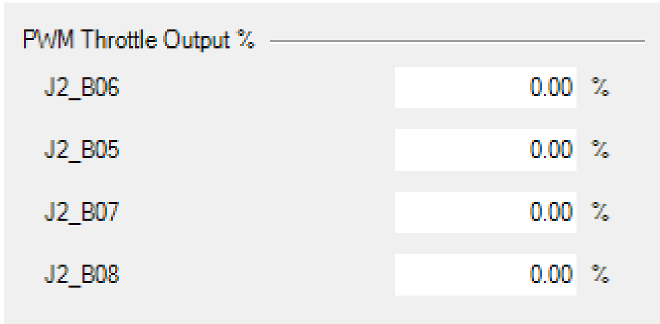
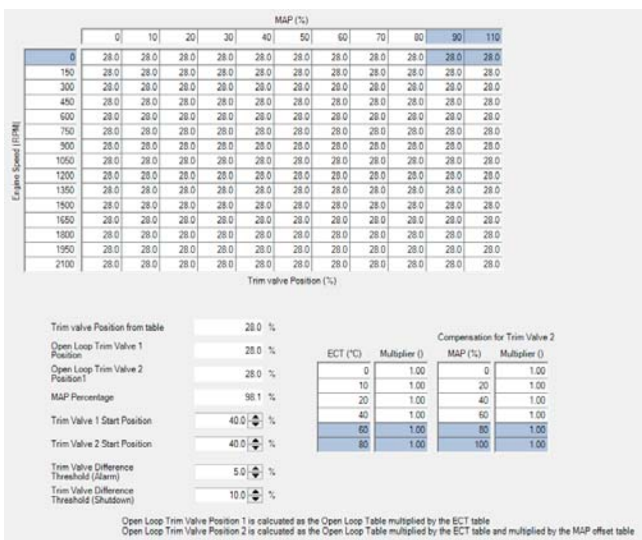


Figure 2-17. PWM Throttle Outputs

1.1- TRIM VALVE OPEN LOOP

The trim valve position vs speed and load table will be the trim valve command signal when the system is running in open loop (without UEGO or GQCL feedback). The scaling of the axes should be adjusted taking into account the operating range of the engine. The MAP axis should extend to 110% MAP. This allows some margin for excursions above 100% MAP during engine calibration and during transient operation in service.



Engine Speed (RPM) \ MAP (%)	0	10	20	30	40	50	60	70	80	90	110
0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
150	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
300	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
450	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
600	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
750	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
900	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
1050	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
1200	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
1350	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
1500	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
1650	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
1800	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
1950	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
2100	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0

Trim valve Position (%)

Trim valve Position from table	28.0	%
Open Loop Trim Valve 1 Position	28.0	%
Open Loop Trim Valve 2 Position1	28.0	%
MAP Percentage	98.1	%
Trim Valve 1 Start Position	40.0	%
Trim Valve 2 Start Position	40.0	%
Trim Valve Difference Threshold (Alarm)	5.0	%
Trim Valve Difference Threshold (Shutdown)	10.0	%

ECT (°C)	Multiplier ()	Compensation for Trim Valve 2 MAP (%)	Multiplier ()
0	1.00	0	1.00
10	1.00	20	1.00
20	1.00	40	1.00
40	1.00	60	1.00
60	1.00	80	1.00
80	1.00	100	1.00

Open Loop Trim Valve Position 1 is calcuated as the Open Loop Table multiplied by the ECT table
Open Loop Trim Valve Position 2 is calcuated as the Open Loop Table multiplied by the ECT table and multiplied by the MAP offset table

Figure 2-18. 1.1- TRIM VALVE OPEN LOOP

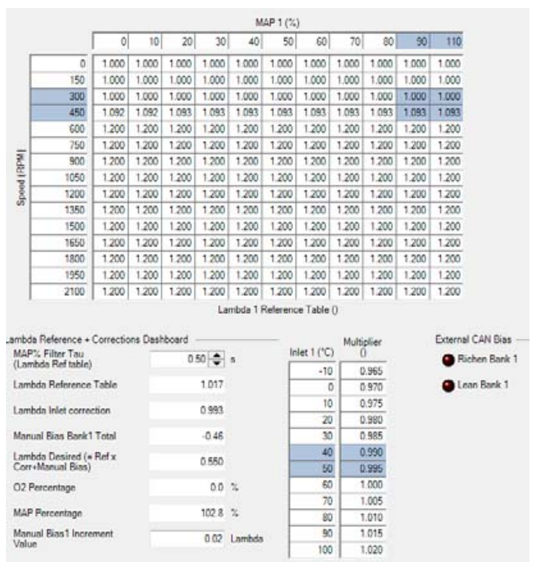
MAP%: Equals MAP1 divided by the MAP Reference (page 1.10) for that speed.
Trim Valve 1 Start Position: The position that Trim Valve 1 will go to when the unit cranks. Once the unit crossing “Run Speed” the valve will ramp to the Open loop table value.
Trim Valve 2 Start Position: The position that Trim Valve 2 will go to when the unit cranks. Once the unit crossing “Run Speed” the valve will ramp to the Open loop table value.
Trim Valve Difference Threshold (Alarm): Percent different in position commands between Trim Valve 1 and Trim Valve 2 before AL_383 TRIM POSITION DIFFERENCE becomes “True”

Trim Valve Difference Threshold (Shutdown): Percent different in position commands between Trim Valve 1 and Trim Valve 2 “AL384 TRIM POSITION DIFF SD” becomes “True”
Table ECT (˚C) Multiplier: Allows the end user to adjust the Open loop table demand
Table: Compensation for Trim Valve 2: Allows the end user to adjust the open loop bias between each bank. This function allows the nominal offsets between the banks of a stereo engine to not influence the Trim Valve difference Alarm/Shutdown logic.

1.2- LAMBDA 1 REFERENCE-UEGO MODE ONLY

Either using an earlier completed table from a similar engine or the engine manufacturer specification sheet is recommended as a starting point. If there is no table available, the required lambda for maximum load on the engine can be entered for high loads and interpolated down to a lambda of 1.1 at no load conditions. Later, during commissioning, these values can be adjusted to the desired performance and emissions.

When making adjustments to the lambda reference entries vs Speed [RPM] and MAP [%], be sure the adjustment is made in the intended speed-load cell.



MAP 1 (%)

Speed (RPM)	0	10	20	30	40	50	60	70	80	90	110
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
150	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
300	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
450	1.092	1.092	1.093	1.093	1.093	1.093	1.093	1.093	1.093	1.093	1.093
600	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
750	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
900	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1050	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1350	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1500	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1650	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1800	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1950	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
2100	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200

Lambda 1 Reference Table ()

Inlet 1 (°C)	Multiplier ()
-10	0.965
0	0.970
10	0.975
20	0.980
30	0.985
40	0.990
50	0.995
60	1.000
70	1.005
80	1.010
90	1.015
100	1.020

Figure 2-19. 1.2- LAMBDA 1 REFERENCE-UEGO MODE ONLY

MAP1%: Equals MAP1 divided by the MAP Reference (page 1.10) for that speed.
MAP% Filter Tau: The MAP% filter time constant can be adjusted to improve engine stability and transient response. Assuming the lambda reference table values are leaner with increasing load (MAP %), increasing this filter will delay the transition to a leaner mixture during upward load transients. The effect of this is to improve the engine’s load acceptance, without adversely affecting steady state emissions. The user is cautioned that if the filter value is set too high the engine can be damaged by running too rich at high load.
Manual Bias 2 Increment Value: The amount the Lambda set point will be increased or decreased when a “Make Rich” or “Make Lean” command is sent over CAN. Typically this signal will come from the optional display available from you local RER.

Manual Bias Total: The total of all the “Make Rich” and “Make Lean” increment commands sent to the control. This value is a global adjustment on the entire Lambda reference table. If specific loads need to be biased then usage of a PC in combination with the service tool is required.
Table Inlet 1 Multiplier: The lambda inlet temperature multiplier should be filled with 1’s for initial start up. During commissioning, the table can be tuned to maintain constant emissions, by manually varying the charge air temperature while monitoring emissions and adjusting the multiplier accordingly. If manually adjusting the inlet temperature is not possible.

a) Take the actual temperature at full load as nominal temperature with a Lambda Inlet correction of 1.000.
b) Then adjust the table as follows:
    i) For every 10 °C higher add 0.005 λ and
    ii) For every 10° lower subtract 0.005 λ.

NOTICE **An engine that is designed for lean burn operation can be damaged if stoichiometric settings are used.**

1.3 – LAMBDA 1 CLOSED LOOP CONTROL SETTINGS

Normally the settings can be left at the default values. If it is observed during commissioning that the correction is too fast or too slow the “Closed Loop Gain” can be adjusted to improve performance.

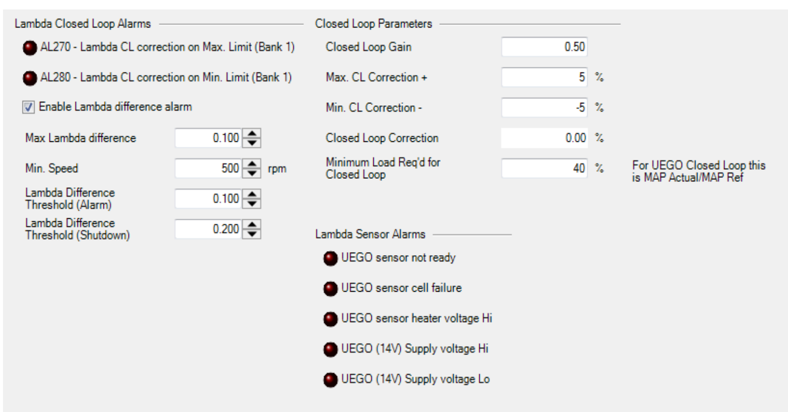


Figure 2-20. Figure . 1.3 – LAMBDA 1 CLOSED LOOP CONTROL SETTINGS

In previous versions of the software the Max. CL Correction +/- was symmetric based on customer feedback there are now two separate tunables allowing asymmetric closed loop correction limits.

Max. CL Correction +: The amount that that the UEGO Closed loop control can increase the Trim Valve 1 command from the Open Loop Table.
Max. CL Correction -: The amount that that the UEGO Closed loop control can decrease the Trim Valve 1 command from the Open Loop Table.

When the box beside “Enable lambda difference alarm” is checked an alarm will be activated when the user specified “Max Lambda difference” is reached. The alarms are disabled at engine speeds below the user specified “Min. Speed”.

Minimum Load Req'd for Closed Loop: A tunable load % value based on either MAP% if running "Pump/Compressor" or kW% if running in "Generator" mode before Lambda Closed Loop is allowed to start. This permissive is new to the control as of revision "C".

1.4- GAS QUALITY CLOSED LOOP- MONO CONFIG ONLY

Overview

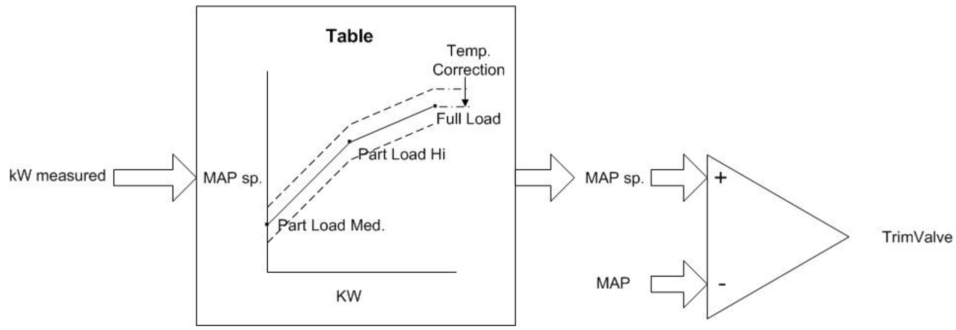


Figure 2-21. Gas Quality Closed Loop Control

Gas Quality Closed Loop (GQCL) uses the measured generator power (kWe), MAP & MAT signals as to infer changes in gas quality. The MAP set point is interpolated from a reference line which is defined by three pole points, Part load Med., Part Load Hi and Full Load. A manifold air temperature correction is applied to the reference line.

GQCL air/fuel ratio control acts in the following manner to maintain manifold pressure in accordance with the set point that is derived from the reference line. When the gas quality increases (i.e. higher energy density), at a constant trim valve set point and thus gas flow the load generated by the engine increases. Hence the actual load increases above that expected for the MAP set point. Due to speed/load control being performed by the E3 system, the throttle will close sufficiently to reduce the speed/load back to the set point. This will effectively also lower the MAP. The difference in MAP set point and MAP measured will generates a correction which results in reduction of the trim valve opening. This will result in the mixture becoming leaner, and the speed/load control will compensate by increasing the throttle opening to maintain the set point, resulting in an increase in MAP. A stable situation will be reached where the MAP measured equals the MAP set point while the MAP, Lambda and mixture flow are essentially the same as before the change. Only the gas flow demand has decreased because of a different trim valve position. When gas quality decreases, the same process works in the opposite direction.

Gas Quality Closed Loop Selections
The Check boxes allow the end user to adjust which mode the control is attempting to use.

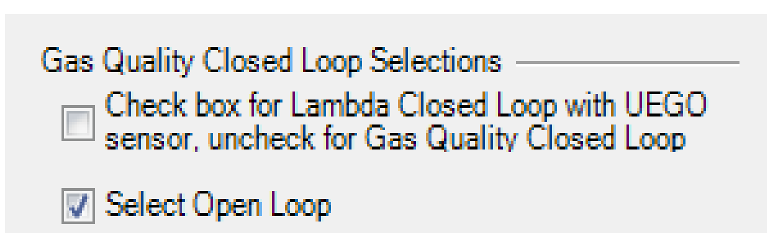


Figure 2-22. Gas Quality Closed Loop Selections

Gas Quality Closed Loop Permissives

There are 5 non-configurable permissives for GQCL to be enabled. In addition there is a configurable check box that allows the user to decide whether a failed MAT1 sensor will cause the control to fault out of GQCL mode.

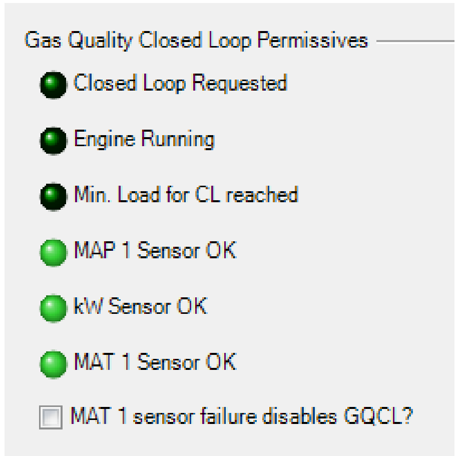


Figure 2-23. Gas Quality Closed Loop Permissives

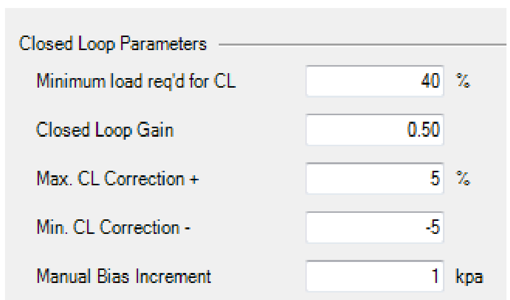


Figure 2-24. Closed Loop Parameters

Minimum Load Req'd for CL: Minimum Load % for GQCL to be enabled. Load % is Actual Load in kW divided by "Maximum Load"
In Previous versions of the software the Max. CL Correction +/- was symmetric based on customer feedback there are now two separate tunables allowing asymmetric closed loop correction limits.

Max. CL Correction +: The amount that that the UEGO Closed loop control can increase the Trim Valve 1 command from the Open Loop Table.
Max. CL Correction -:The amount that that the UEGO Closed loop control can decrease the Trim Valve 1 command from the Open Loop Table.

Manual Bias Increment: The amount that a "Make Rich" or "Make Lean" increment command will change the desired Manifold pressure from the values entered in the table.

Inlet Air Temperature Compensation

In normal operation, there are differences between the manifold mixture temperature (the measured MAT) and the actual mixture temperature as it enters the cylinders (the Inlet Air Temperature – IAT). This is caused by heat transfer to the intake charge due to contact with engine parts that have a coolant temperature-related surface temperature, such as the cylinder head intake ports. Since the temperature will change from the measured MAT, a correction is needed to get an accurate approximation of IAT.

There is a selection between a calculation of IAT or a manually entered transfer function table. By default the calculation is selected
When the ECT is measured the inlet temperature is directly calculated from the MAT, ECT and the temperature gain.

Temp.Gain = 0	IAT = MAT
Temp.Gain = 1	IAT = ECT

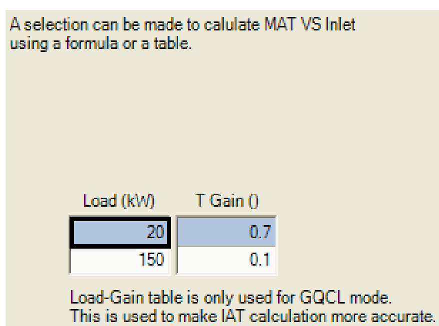
When the gain is between 0 and 1, the IAT is a linear interpolation between MAT and ECT.

If the ECT is not measured (not used, or ECT sensor voltage out of range), it is estimated from the reference ECT and the warm-up time

The ECT estimation is done using the MAT, the reference temperature (ECT @ sensor failure) and the warm-up time. When the engine is running, the estimated ECT is linearly increased from MAT to the reference temperature, during the warm-up time. When the engine stops, the estimated ECT is reduced back to MAT over the warm-up time. The estimated ECT is then used instead of measured ECT, to determine IAT.

Because of increased airflow at higher loads the influence of engine temperature on IAT is reduced. To get the most accurate estimation of IAT, which is important for GQCL the “Tgain” value can be adjusted over the load range.

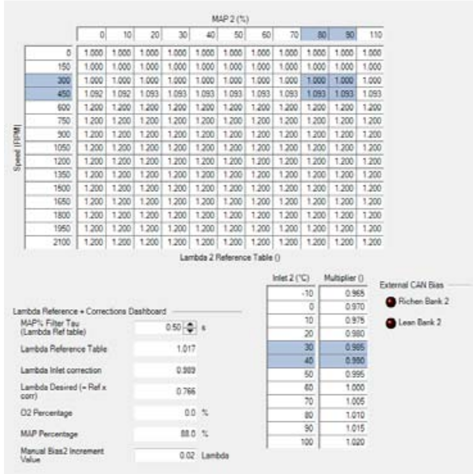
This setting is only used in GQCL mode.



1.5- LAMBDA 2 REFERENCE-UEGO CLOSED LOOP

This page is a mirror image of page 1.2. The tunables on page affect the second fuel control loop on a stereo engine. To fill in the table use the values from page 1.2 as a starting point.

Later, during commissioning, these values can be adjusted to the desired performance and emissions.



Speed (RPM) \ MAP 2 (%)	0	10	20	30	40	50	60	70	80	90	110
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
150	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
300	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
450	1.092	1.092	1.093	1.093	1.093	1.093	1.093	1.093	1.093	1.093	1.093
600	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
750	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
900	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1050	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1350	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1500	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1650	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1800	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
1950	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
2100	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200

Inlet 2 (°C)	Multiplier ()
-10	0.965
0	0.970
10	0.975
20	0.980
30	0.985
40	0.990
50	0.995
60	1.000
70	1.005
80	1.010
90	1.015
100	1.020

Figure 2-25. 1.5- LAMBDA 2 REFERENCE-UEGO MODE ONLY

MAP2%: Equals MAP2 divided by the MAP Reference (page 1.10) for that speed.
MAP% Filter Tau: The MAP% filter time constant can be adjusted to improve engine stability and transient response. Assuming the lambda reference table values are leaner with increasing load (MAP %), increasing this filter will delay the transition to a leaner mixture during upward load transients. The effect of this is to improve the engine's load acceptance, without adversely affecting steady state emissions. The user is cautioned that if the filter value is set too high the engine can be damaged by running too rich at high load.
Manual Bias 2 Increment Value: The amount the Lambda set point will be increased or decreased when a "Make Rich" or "Make Lean" command is sent over CAN. Typically this signal will come from the optional display available from you local RER.
Manual Bias Total: The total of all the "Make Rich" and "Make Lean" increment commands sent to the control. This value is a global adjustment on the entire Lambda reference table. If specific loads need to be biased then usage of a PC in combination with the service tool is required.
Table Inlet 1 Multiplier: The lambda inlet temperature multiplier should be filled with 1's for initial start up. During commissioning, the table can be tuned to maintain constant emissions, by manually varying the charge air temperature while monitoring emissions and adjusting the multiplier accordingly. If manually adjusting the inlet temperature is not possible.

a) Take the actual temperature at full load as nominal temperature with a Lambda Inlet correction of 1.000.
b) Then adjust the table as follows:
    i) For every 10 °C higher add 0.005 λ and
    ii) For every 10° lower subtract 0.005 λ.

1.6 – LAMBDA 2 CLOSED LOOP CONTROL SETTINGS

Normally the settings can be left at the default values. If it is observed during commissioning that the correction is too fast or too slow the "Closed Loop Gain" can be adjusted to improve performance.

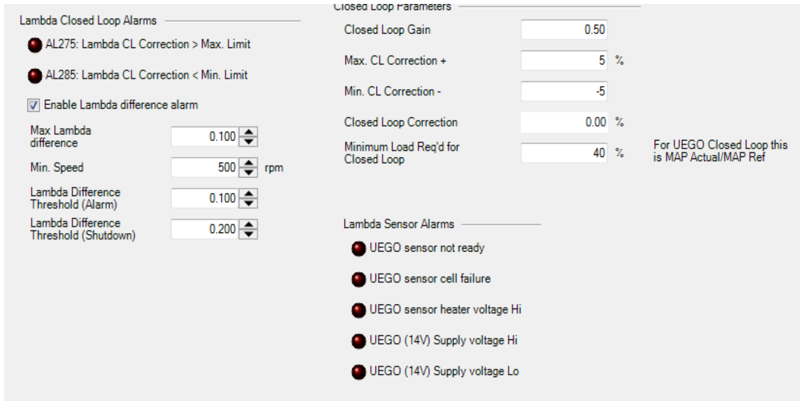


Figure 2-26. 1.3 – LAMBDA 1 CLOSED LOOP CONTROL SETTINGS

In Previous versions of the software the Max. CL Correction +/- was symmetric based on customer feedback there are now two separate tunables allowing asymmetric closed loop correction limits.

The CL Correction Limits are common for Lambda 1/2 Closed loop.

Max. CL Correction +: The amount that that the UEGO Closed loop control can increase the Trim Valve 2 command from the Open Loop Table.
Max. CL Correction -: The amount that the UEGO Closed loop control can decrease the Trim Valve 2 command from the Open Loop Table.

When the box beside “Enable lambda difference alarm” is checked an alarm will be activated when the user specified “Max Lambda difference” is reached. The alarms are disabled at engine speeds below the user specified “Min. Speed”.
Minimum Load Req’d for Closed Loop: A tunable load % value before Lambda Closed Loop is allowed to start. This permissive is new to the control as of revision “C”.

1.7- TRIM VALVE 1 ADAPTIVE LEARN

Adaptive learn should be disabled for first engine startup by checking the box next to “Disable Adaptive Learn” and clicking the box next to “Reset Adaptive Learn Table”.

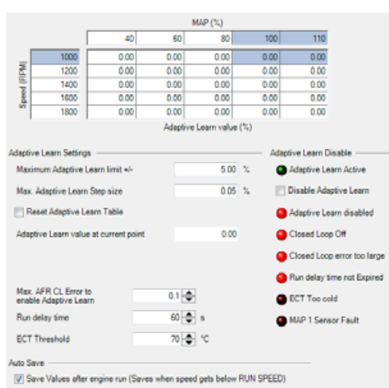


Figure 2-27. 1.8- TRIM VALVE 2 ADAPTIVE LEARN

1.8- TRIM VALVE 2 ADAPTIVE LEARN

Adaptive learn should be disabled for first engine startup by checking the box next to “Disable Adaptive Learn” and clicking the box next to “Reset Adaptive Learn Table”.

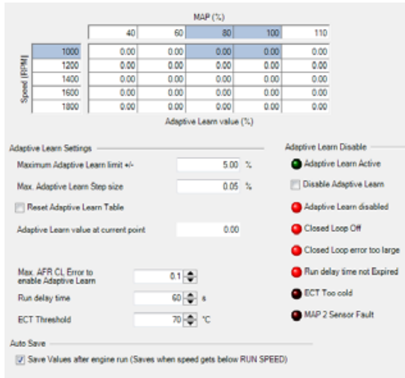


Figure 2-28. 1.8- TRIM VALVE 2 ADAPTIVE LEARN

1.9- TRANSIENT COMPENSATION

Transient fuel compensation is used to compensate for significant load steps. This compensation can provide improved dynamic response during moderate to severe transient events through judicious tuning of the control parameters.
The transient logic acts on the time derivative of MAP (dMAP/dt) which is used to trigger an upward or downward fuel pulse during the transient.

Transient Compensation Setup

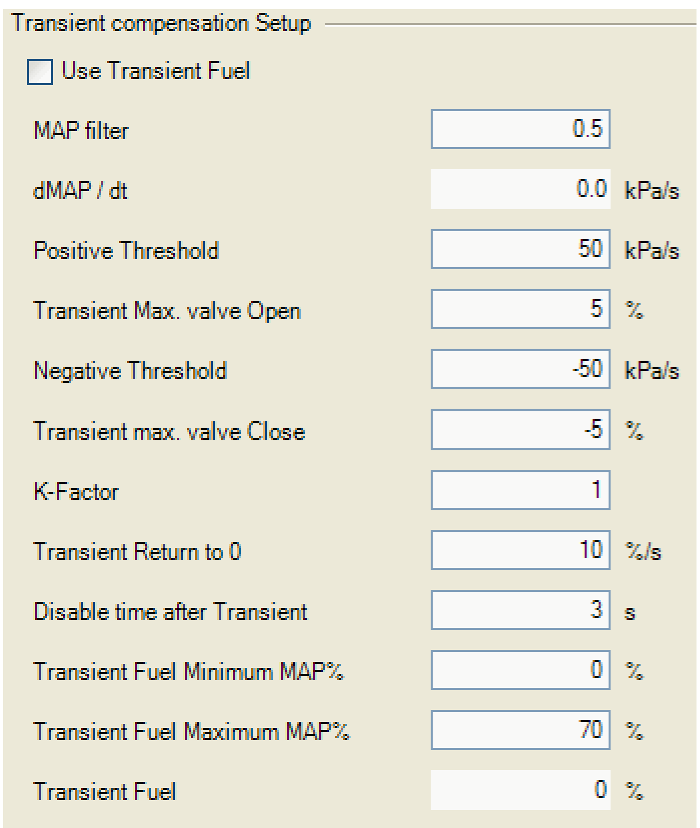


Figure 2-29. Transient Logic Basic Settings (HMI Screen 1.6)

The HMI settings for user configuration of transient fueling logic are shown in Figure 2-29. Transient logic is disabled by unchecking the box beside “Use Transient Fuel”. Adjustment of the parameters to give the desired correction to the gas flow can prove difficult because of the lag time in the single point mixing system. Filtered dMAP/dt is calculated, and when this value exceeds the user specified positive or negative threshold, a corresponding upward or downward fuel pulse is generated (via trim valve control). Transient fueling should be calibrated during maximum and nominal load steps in accordance with the observed rate of change in the MAP signal during these transients. The MAP signal behavior under these conditions determines the setting of the dMAP/dt thresholds. When the dMAP/dt exceeds the threshold the value of dMAP/dt is multiplied with the “K-Factor”, i.e. the gain. This is the Bias value added to the Trim valve position command. This compensation applies to both positive and negative dMAP/dt.

The higher the gain, the higher the compensation value will be. The threshold value determines the minimum point where the bias becomes active, but it also influences the length of time that the bias is active. When the threshold is reduced, the bias will be active for a longer duration.

When the filter setting is tuned to a high value, along with a low setting of the threshold transient limit this will result in a lower dMAP/dt, so the bias will be lower, while dMAP/dt will remain longer above this limit and will thus result in a longer bias pulse.

Load Rejection Setup

This feature is designed to be used when the generator breaker is opened unexpectedly while under load to keep unit out of an overspeed condition. The load rejection function pulses the mixture throttle closed when the load is above the user specified “Pulse active above load” (% of rated kW) and the generator breaker opens. The mixture throttle will pulse from the PID controlled position to the user specified “Max. throttle position” for the user specified “Actuator pulse time”.

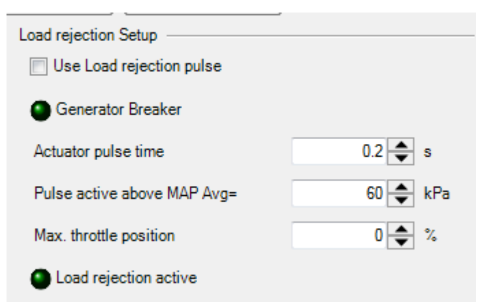


Figure 2-30. Load Rejection Setup

Actuator Pulse Time: Time throttle set point is set to Max. Throttle Position (0.2-0.4 is a typical value).
Pulse Active MAP Average: Manifold air pressure that the unit must be running above for the load rejection pulse to become active open the generator breaker opening.
Max. Throttle Position: This value is the set point to the throttle for the Actuator pulse time span. This value is typically left at “0.0” and the Actuator pulse time is tuned.

1.10- TORQUE LIMIT (MAP REFERENCE)

Speed (RPM)	MAP Reference (kPa)
1000	40
1100	60
1200	80
1300	110
1400	125
1500	150
1600	175
1700	200
1800	225
1900	250
2000	300

Figure 2-31.1.10- TORQUE LIMIT (MAP REFERENCE)

The maximum fuel limit is determined in the torque limiter (Map Reference) curve MAP Reference is the maximum MAP the engine is allowed to reach, via control of the throttle. Because air/fuel ratio is always controlled, MAP Reference or limit is also a fuel limit. These settings define the torque curve of the engine. This is important for mechanical drive applications.

The MAP Reference value is also used to calculated MAP % which is used in the trim valve open loop table and the lambda reference table. For generator applications the maximum manifold pressure allowed at synchronous speed should be entered at all speed values of the MAP Reference table.

MAP REFERENCE

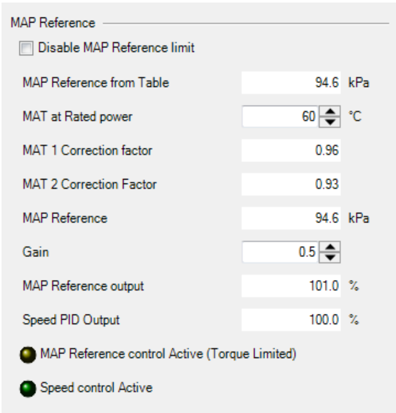


Figure 2-32. MAP REFERENCE

MAT at Rated Power: The manifold air temperature at rated power.

2.1- SPEED CONTROL SETTINGS

Setpoints

Generator Application Mode and Pump/Compressor Application Mode
The speed reference can be adjusted between user specified limits for minimum and maximum speed via discrete raise and lower inputs or an analog remote reference input.

Generator Application Mode
When “Generator Application Mode” is selected and the engine is started it will go through the normal start-up routine. Upon starting it will accelerate to the user input value for “Minimum Speed ref/Idle” and remain there for a tunable warm-up/delay time. After this time expires the reference will ramp up to the calibrated rated speed.

Pump/Compressor Application Mode
When “Pump/Compressor Application Mode” is selected and the engine is started it will accelerate to the user input value for “Minimum Speed ref/Idle” and remain at that speed until a signal is received on the raise speed input.

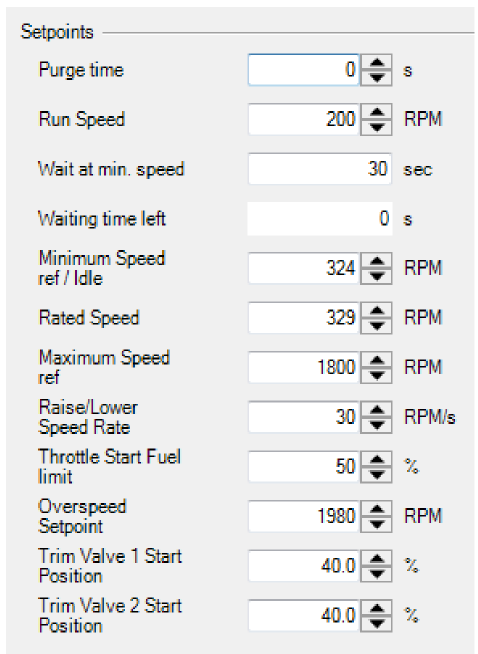


Figure 2-33. Speed Control Settings

Purge Time: The time interval after engine cranking is detected before the main gas shutoff valve is opened. This allows the engine to be purged with air to provide for a safe startup condition.

If the IC-920 ignition system is used, the main gas shutoff valve signal should also be wired into the IC-920 “Contact A” to prevent the ignition from firing before the purge time has expired.

Run Speed: The engine speed at which the speed control PID becomes active (typically 350-450 for industrial gas engines)

Idle Speed Selection

Generator Application Mode and Pump/Compressor Application Mode
Idle speed is selected under following conditions:
- Discrete input Idle/Rated is active (TRUE = contact closed)
- When the engine is stopped

Generator Application Mode
Idle speed is selected under following conditions:
- Engine speed is below the user input value for “RunSpeed” and the generator breaker is open

When the idle warm-up timer (user entered value “Wait at min. speed”) is expired the speed reference will ramp up to rated with the Accel/Decel rate. When rated speed is reached the rate will switch to the raise/lower rate. This is usually a lot slower, to allow synchronization of the unit. When selecting Idle with the discrete input, it will ramp down with the Accel/Decel rate to idle again, until this condition is removed.

Pump/Compressor Application Mode
Idle speed is selected when the speed reference is reduced to “Minimum Speed Ref/Idle” via the lower speed discrete input or the analog remote speed reference input.

When the idle warm-up timer (user entered value “Wait at min. speed”) is expired the speed reference will remain at the user input value for “Minimum Speed” until a signal is received on the raise speed input.

Rated Speed Selection – Generator application only
Rated speed is selected under following conditions:
- Idle speed is reached and Idle delay/warm-up timer is expired or,
- Generator breaker is closed and the “Droop Mode (Dual Dynamics)” is not checked (isochronous mode) or,
- Upon opening of the generator breaker (causing a reset to rated)

When the reference is ramping up and the operator activates a raise or lower discrete input, it will stop the automatic ramp to rated and remain at that set point. The reference then can be adjusted using the raise or lower inputs. The ramp to rated speed uses the Acceleration/Deceleration Rate settings.

Raise and Lower Speed Rate
It is possible to change the speed reference with the raise and lower inputs. These inputs are active when:
- Generator breaker input is open – Generator application only.
- Idle delay timer has expired (warm-up has been performed).
- Remote Speed Setting Input is not Active

The limits are the “Minimum Speed ref/Idle” and “Maximum Speed ref”, as described above. The user specified value for “Raise/Lower Speed Rate” is used in this case.

Throttle Start Fuel Limit: Position throttle will be in between 50 rpm and Run Speed
Overspeed Setpoint: Speed of the engine at which SD80 Overspeed becomes active and all actuator demand signals are driven to “0” and the Fuel Shutoff valve is commanded closed.
Trim Valve 2 Start Position: Position Trim Valve 2 will be in between 50 rpm and Run Speed

Trim Valve 2 Start Position: Position Trim Valve 2 will be in between 50 rpm and Run Speed

Remote speed setting selection
Remote speed setting is selected when all of the following conditions are simultaneously met:

- Raise and lower inputs are both active for more than 2 seconds
- Idle delay timer has expired
- Breaker is open or "Droop Mode (Dual Dynamics)" is selected – Generator application only
- AL190 (Speed/Load ref min voltage) and AL200 (Speed/Load ref max voltage) alarms are both inactive
- The discrete input Idle/Rated is not active

Under these conditions the speed reference will first ramp to idle speed and then remain there for the warm-up during the tuned delay time. After the timer expires, it will ramp to the remote input setting with the "Raise/Lower Speed Rate" (the reference will not change to rated speed in this case). This option can also be used in mechanical drive applications, except that the speed reference will remain at idle after the tuned delay time.

The remote setting can also be made active after the generator breaker is closed. The remote setting will then change the load on the generator as described in the droop mode below.

When either of the remote input alarms is active (AL190 "Remote Reference voltage Low" or AL200 "Remote Reference voltage Hi") the reference will stay at that point. The speed reference can then only be adjusted with the raise and lower inputs. The limits are the raise and lower speed limits, as adjusted for the raise and lower discrete input contacts.

The Raise/Lower Speed Rate is also applied when changing the speed reference in Remote mode.

Droop Mode - Generator Application Only
It is possible to run the control in droop mode. To do this, the engine needs to be synchronized to the grid by using raise or lower speed inputs or the speed bias and closing the utility breaker.

The control needs to remain in Speed control mode (utility breaker open).

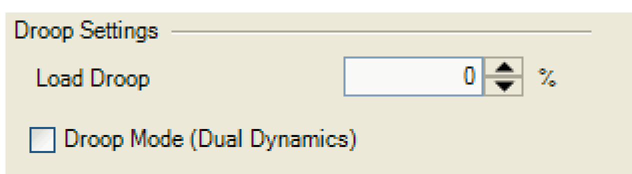


Figure 2-34. Droop Settings (HMI Screen 2.1)

Droop Mode with Dual Dynamics (using Dynamics 1 and Dynamics 2)
In this mode the generator breaker position is monitored. To make possible switching between Dynamics 1 and Dynamics 2 in droop mode, the generator breaker input must be connected and the checkbox "Droop Mode (Dual Dynamics)" must be checked. The following methods can be used to change the speed reference in this mode: Raise/Lower discrete contacts, the speed bias input when configured correctly and the Remote speed reference input. A suggested starting load droop percentage is 5%.

In this mode the speed reference is not set to rated when the breaker closes, there is only a reset to rated when the breaker opens (allowing different grid frequencies and improved load rejection performance).

2.2- SPEED CONTROL FIXED DYNAMICS

When fixed P, I, and D gains are selected in the SPEED CONTROL FIXED DYNAMICS HMI user settings (Figure 2-35), the selected fixed gains are independent of the run mode of the engine (generator breaker and utility breaker positions). Also the load and PID% have no influence on the selected fixed gains.

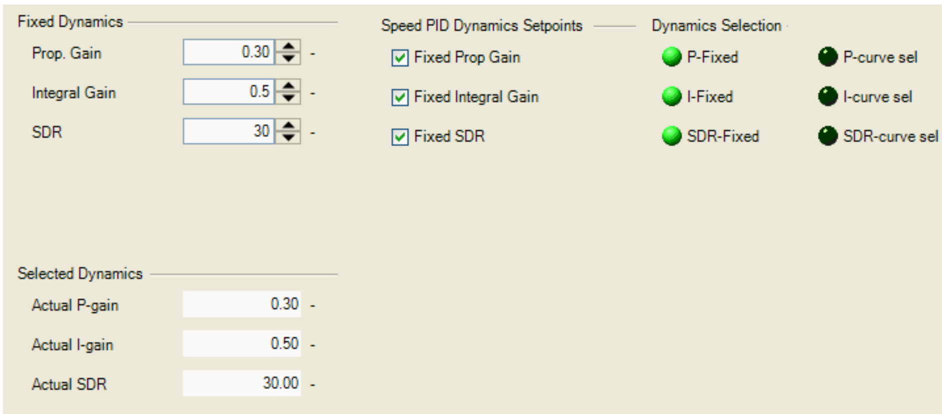


Figure 2-35. Fixed Dynamics Settings

2.3- SPEED CONTROL CURVE DYNAMICS 1

Dynamics 1 allows adjustments to Prop Gain, Integral Gain, and SDR based on the MAP%. These dynamics are active when both breaker contacts (Gen and Utility) are open.

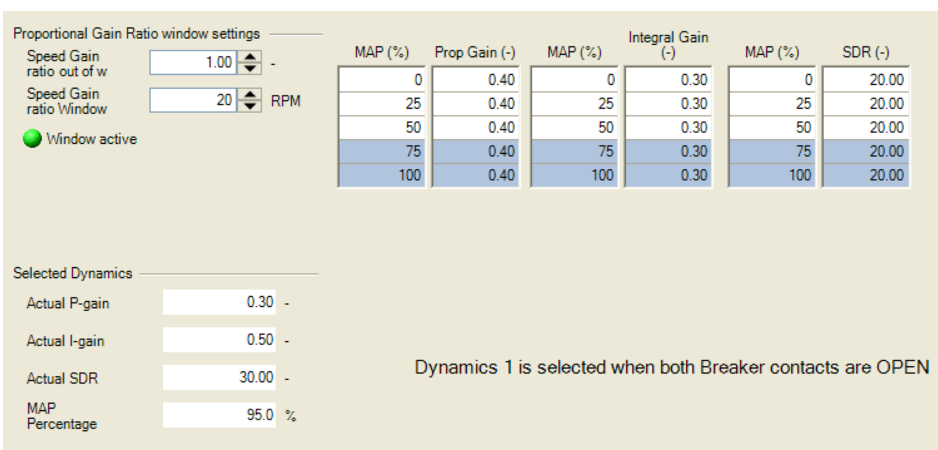


Figure 2-36. SPEED CONTROL CURVE DYNAMICS 1

2.4 SPEED CONTROL CURVE DYNAMICS 2

Similar to Dynamics 1, except they are used when the generator breaker is closed but the engine is still in speed control mode.

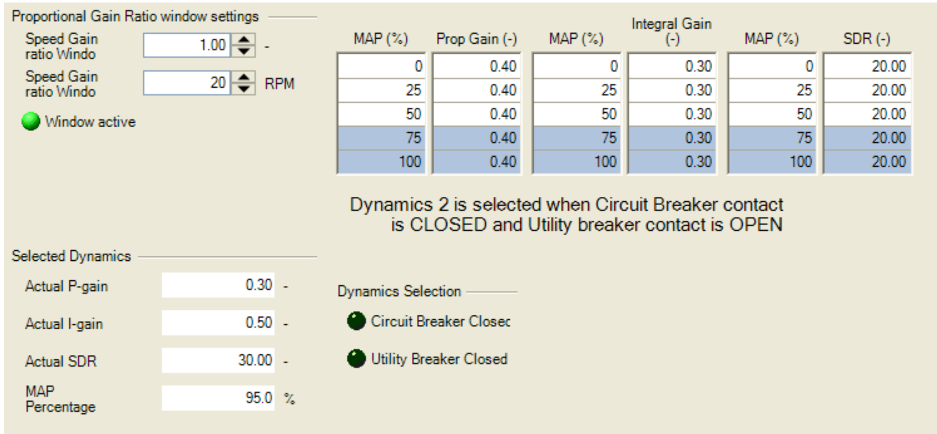


Figure 2-37. SPEED CONTROL CURVE DYNAMICS 2

2.5 KW LOAD CONTROL SETTINGS

The load reference is active only when in load (grid) control mode, i.e. when the generator breaker and utility breaker discrete inputs are closed. Both the generator and the grid breaker inputs need to be closed. The load reference can then be changed with the raise and lower inputs, or with the remote load reference input if enabled and active.

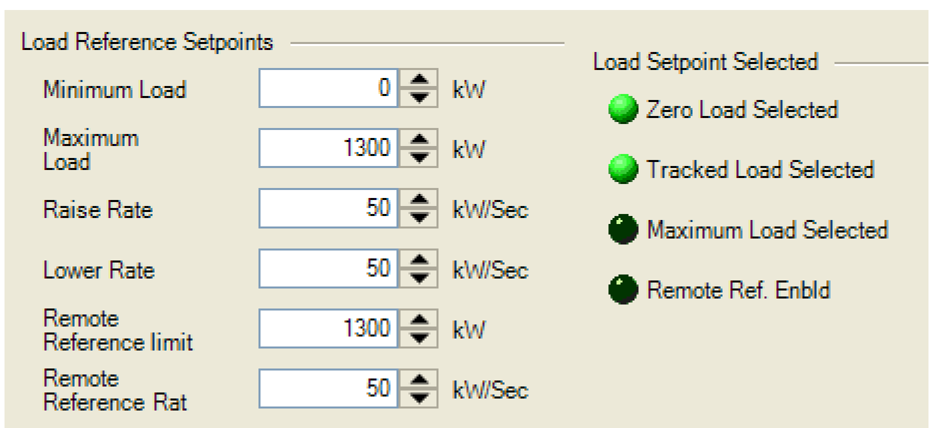


Figure 2-38. Load Reference Setpoints

When running in Load Control (Grid mode) mode, the plant/island electrical bus is connected to the grid via the utility breaker (both breaker feedback inputs are TRUE). When the engine is configured as a droop system in island mode (utility breaker open), this means that the Speed set point + Droop to PID will change depending on the droop percentage that is configured and the base load (island load) that is required. This speed set point will be lower than the rated speed set point. When the utility breaker is opened and the system goes into island mode, it depends on the island load what the resulting speed set point will be. It will be lower than the rated speed frequency but this also depends on the droop percentage and the actual island load.

For example:

Droop % = 3%
Total load = 1000 kW
Plant load = 300 kW
Rated Speed = 1500 rpm

When the engine runs in Load Control (Grid mode) mode with both the utility and generator breaker closed the total load is 1000 kW (300 kW island load + 700 kW exported to the grid). With 3% droop, this gives a resulting speed set point of 1500 – 30 = 1470 rpm. The control measures the new actual plant load of 300 kW. This gives a new speed set point of 1500 – 9 = 1491 rpm. To get to the rated speed set point, the operator needs to raise the speed setting manually. When more engines are connected to the plant and configured as droop system, an equal droop percentage for all engines is required to divide the load in the above-mentioned situation. When only one engine is on the plant bus, it is better to configure 0% droop (isochronous operation), so no speed change is seen when switching from Load Control (Grid mode) to speed control.

Raise and Lower inputs
It is possible to change the load setting with the raise and lower inputs. These inputs are active when:

- Generator breaker and the grid breaker are both closed (On Grid).
- Remote load setting input is not active

When the remote load setting is activated at a certain point of load, the reference will switch to the remote set point and then move with the change of the set point. The ramp rates used in this mode are the user specified raise and lower rates.

Remote load setting selection
Remote load setting is selected under following conditions:

- Raise and lower inputs are both active (enabled/TRUE)
- Generator breaker is closed
- Grid breaker is closed.
- AL190 (Speed/Load ref min voltage) and AL200 (Speed/Load ref max voltage) alarms are both inactive.

The ramp rate used in this mode is the user specified value for “Remote Reference Rate”. There is also a limiter that can be used to limit the remote setting. This is tuned in the “Remote Reference Limit”. When deactivating the remote setting, it will remain at that load point until it is changed using the raise or lower inputs.

2.6 LOAD CONTROL CURVE DYNAMICS 3

Dynamics 3 is based on a load error that is compared to an absolute load window. The box beside “Enable KW Dynamics” needs to be checked to activate Dynamics 3. When this box is not checked the control will use Dynamics 2 regardless of the grid breaker status.

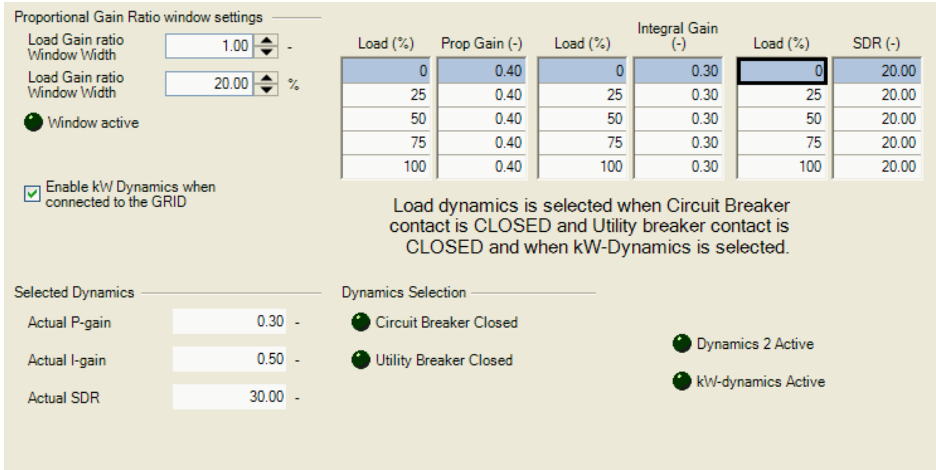


Figure 2-39. LOAD CONTROL SETTINGS

2.7 MAP BIAS

The manifold air pressure bias logic allows users of stereo engines equipped with a single throttle actuator per bank to balance the load on each bank. The Throttle1 command acts as the leading value to the Throttle2. A slow control loop then adjusts Throttle2 position command until MAP1 equals MAP2.

Figure 2-40. MAP BIAS Settings

2.8- MAP BIAS ADAPTIVE LEARN

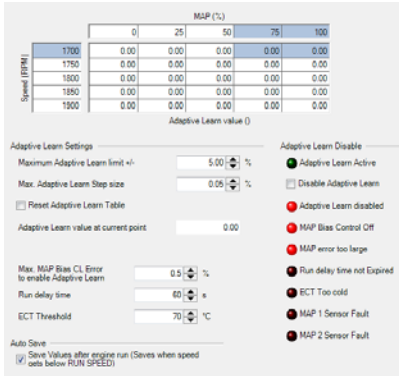


Figure 2-41. Map Bias Adaptive Settings

3.1- THROTTLE1 SETUP

For each actuator the end can select from multiple options for the command signal. A Low current PWM output is available to drive L-series, F-series, P-series FL, ProAct Digital Plus, or a 3rd party device.

In addition J1939 CAN is supported for F-series and ProAct actuators.

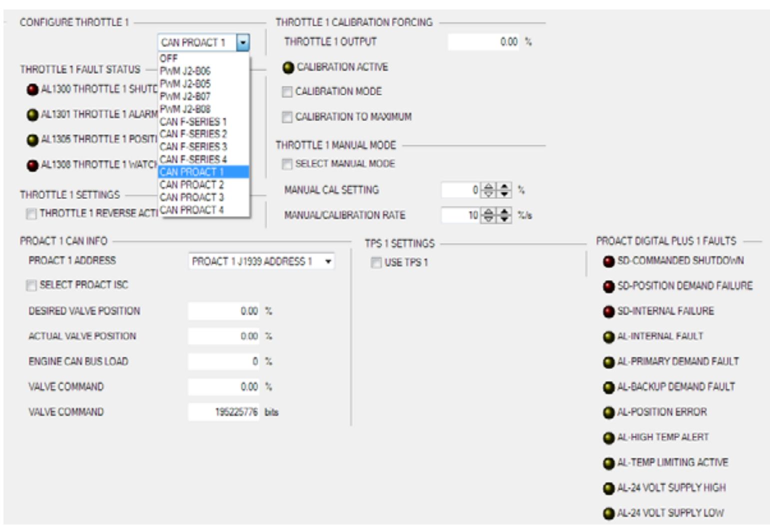


Figure 2-42. THROTTLE1 SETUP

THROTTLE1 CALIBRATION FORCING

If using a Woodward L-series, F-series, or ProAct calibration is not necessary.

1. Set Calibration Mode ON
2. Tune the “Throttle at minimum position” so that the valve is mechanically fully closed. This should be checked visually on the valve if possible. Record the TPS voltage on the HMI and tune the “TPS at minimum.” value to this voltage.
3. Select “Throttle to maximum” and tune the “Throttle at maximum position” value so that the valve is just mechanically fully open. This should be visually checked on the valve if possible.

4. Record the TPS voltage on the HMI and tune the "TPS at maximum position" value to this voltage.
5. Save Values and set the Calibration OFF.

The THROTTLE1 MANUAL MODE tunables on this page are useful for verifying correct signal command mapping.

TPS1 Signal Input

The TPS1 feedback signal is a dedicated analog input that recommended for analog-controlled (non-J1939) throttle actuators. The TPS1 feedback signal is not needed for a J1939-controlled actuator and is disregarded when a J1939 throttle actuator is used.

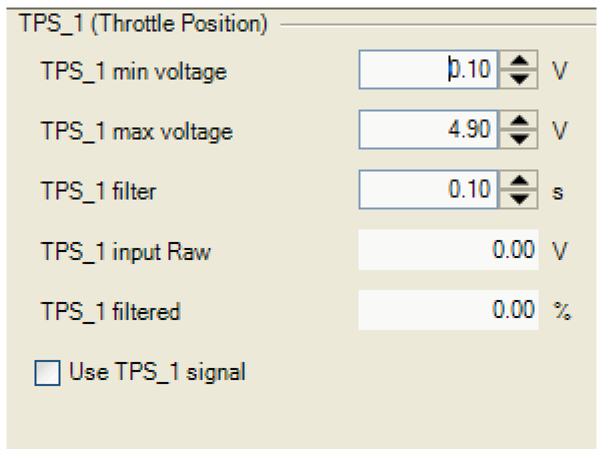


Figure 2-43. TPS1 Signal Configuration

Use TPS_1 signal: Enables the TPS1 functionality.
TPS_1 min voltage: The alarm threshold value for the low voltage diagnostic. Defaults 0.10 V.
TPS_1 max voltage: The alarm threshold value for the high voltage diagnostic. Default is 4.9 V.
TPS_1 filter: Filter that can be entered to filter noise from the input signal.
Upon signal failure the TPS1 input will be set to zero.

3.2- THROTTLE2 SETUP

For each actuator the end can select from multiple options for the command signal. A Low current PWM output is available to drive L-series, F-series, P-series FL, ProAct Digital Plus, or a 3rd party device.

In addition J1939 CAN is supported for F-series and ProAct actuators.

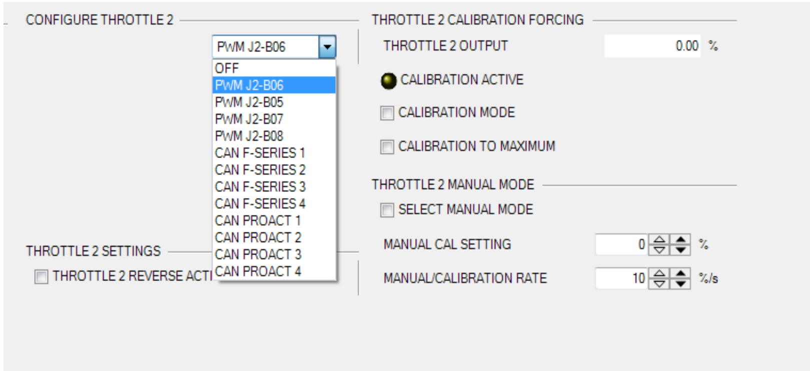


Figure 2-44. THROTTLE2 SETUP

THROTTLE2 CALIBRATION FORCING
If using a Woodward L-series, F-series, or ProAct calibration is not necessary.

6. Set Calibration Mode ON
7. Tune the “Throttle at minimum position” so that the valve is mechanically fully closed. This should be checked visually on the valve if possible. Record the TPS voltage on the HMI and tune the “TPS at minimum.” value to this voltage.
8. Select “Throttle to maximum” and tune the “Throttle at maximum position” value so that the valve is just mechanically fully open. This should be visually checked on the valve if possible.
9. Record the TPS voltage on the HMI and tune the “TPS at maximum position” value to this voltage.
10. Save Values and set the Calibration OFF.

The THROTTLE2 MANUAL MODE tunables on this page are useful for verifying correct signal command mapping.

TPS2 Signal Input

The TPS2 feedback signal is a dedicated analog input that recommended for analog-controlled (non-J1939) throttle actuators. The TPS2 feedback signal is not needed for a J1939-controlled actuator and is disregarded when a J1939 throttle actuator is used.

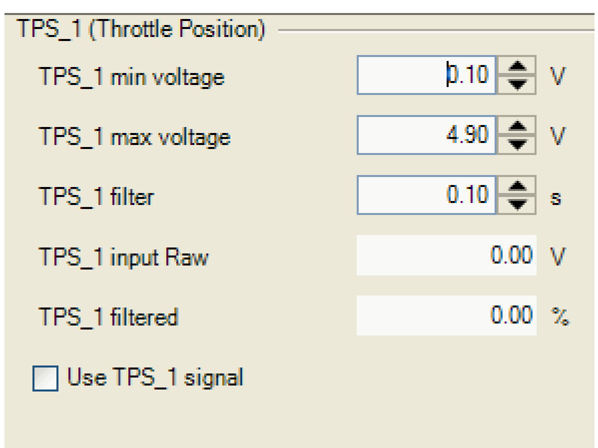


Figure 2-45. TPS2 Signal Configuration

Use TPS_2 signal: Enables the TPS2 functionality.
TPS_2 min voltage: The alarm threshold value for the low voltage diagnostic. Defaults 0.10 V.
TPS_2 max voltage: The alarm threshold value for the high voltage diagnostic. Default is 4.9 V.
TPS_2 filter: Filter that can be entered to filter noise from the input signal.
Upon signal failure the TPS2 input will be set to zero.

3.3- FUEL TRIM VALVE 1 SETUP

For each actuator the end can select from multiple options for the command signal. A Low current PWM output is available to drive L-series, F-series, P-series FL, ProAct Digital Plus, or a 3rd party device.

In addition J1939 CAN is supported for F-series and ProAct actuators.

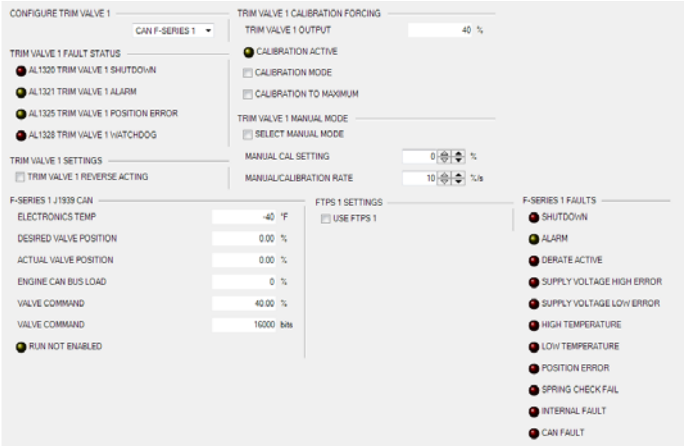


Figure 2-46. FUEL TRIM VALVE 1 SETUP

FUEL TRIM VALVE 1 CALIBRATION FORCING
If using a Woodward L-series, F-series, or ProAct calibration is not necessary.

11. Set Calibration Mode ON
12. Tune the "Throttle at minimum position" so that the valve is mechanically fully closed. This should be checked visually on the valve if possible. Record the TPS voltage on the HMI and tune the "TPS at minimum." value to this voltage.
13. Select "Throttle to maximum" and tune the "Throttle at maximum position" value so that the valve is just mechanically fully open. This should be visually checked on the valve if possible.
14. Record the TPS voltage on the HMI and tune the "TPS at maximum position" value to this voltage.
15. Save Values and set the Calibration OFF.

The FUEL TRIM VALVE 1 MANUAL MODE tunables on this page are useful for verifying correct signal command mapping.

FTPS1 Signal Input

The FTPS1 feedback signal is a dedicated analog input that recommended for analog-controlled (non-J1939) throttle actuators. The FTPS1 feedback signal is not needed for a J1939-controlled actuator and is disregarded when a J1939 throttle actuator is used.

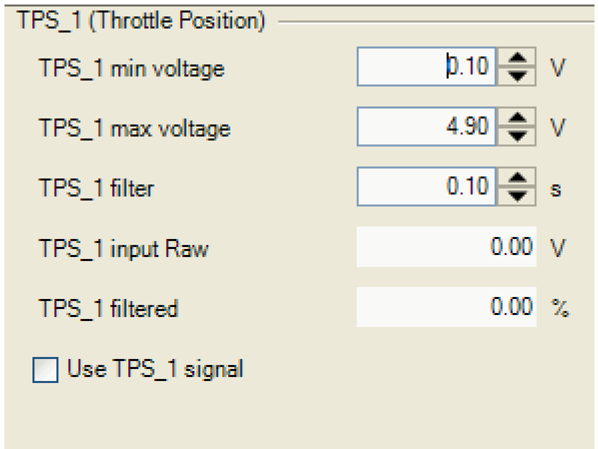


Figure 2-47. FTPS1 Signal Configuration

Use FTPS_1 signal: Enables the FTPS1 functionality.
FTPS_1 min voltage: The alarm threshold value for the low voltage diagnostic. Defaults 0.10 V.
FTPS_1 max voltage: The alarm threshold value for the high voltage diagnostic. Default is 4.9 V.
FTPS_1 filter: Filter that can be entered to filter noise from the input signal.
Upon signal failure the FTPS1 input will be set to zero.

3.4- FUEL TRIM VALVE 2 SETUP

For each actuator the end can select from multiple options for the command signal. A Low current PWM output is available to drive L-series, F-series, P-series FL, ProAct Digital Plus, or a 3rd party device.

In addition J1939 CAN is supported for F-series and ProAct actuators.

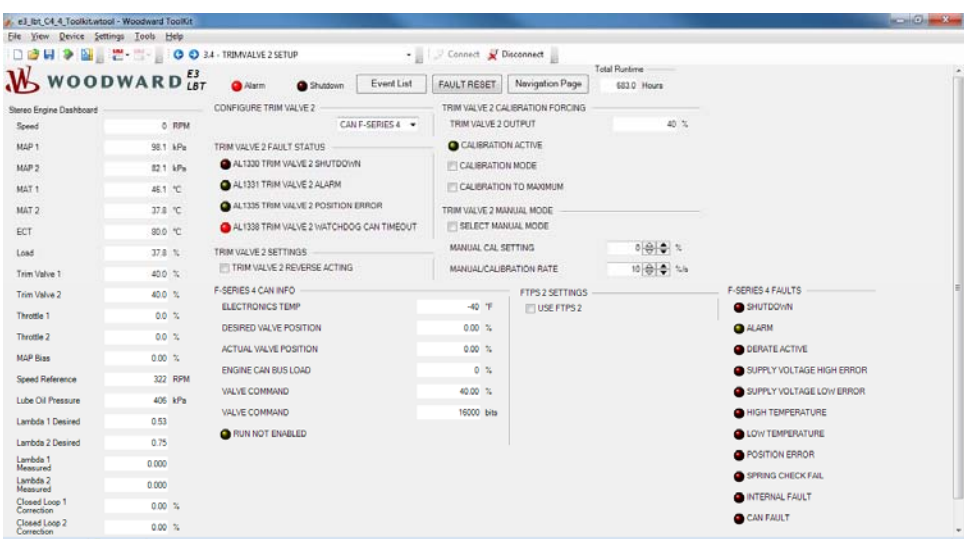


Figure 2-48. FUEL TRIM VALVE 2 SETUP

FUEL TRIM VALVE 2 CALIBRATION FORCING
If using a Woodward L-series, F-series, or ProAct calibration is not necessary.

16. Set Calibration Mode ON
17. Tune the “Throttle at minimum position” so that the valve is mechanically fully closed. This should be checked visually on the valve if possible. Record the TPS voltage on the HMI and tune the “TPS at minimum.” value to this voltage.
18. Select “Throttle to maximum” and tune the “Throttle at maximum position” value so that the valve is just mechanically fully open. This should be visually checked on the valve if possible.
19. Record the TPS voltage on the HMI and tune the “TPS at maximum position” value to this voltage.
20. Save Values and set the Calibration OFF.

The FUEL TRIM VALVE 2 MANUAL MODE tunables on this page are useful for verifying correct signal command mapping.

FTPS2 Signal Input

The FTPS2 feedback signal is a dedicated analog input that recommended for analog-controlled (non-J1939) throttle actuators. The FTPS2 feedback signal is not needed for a J1939-controlled actuator and is disregarded when a J1939 throttle actuator is used.

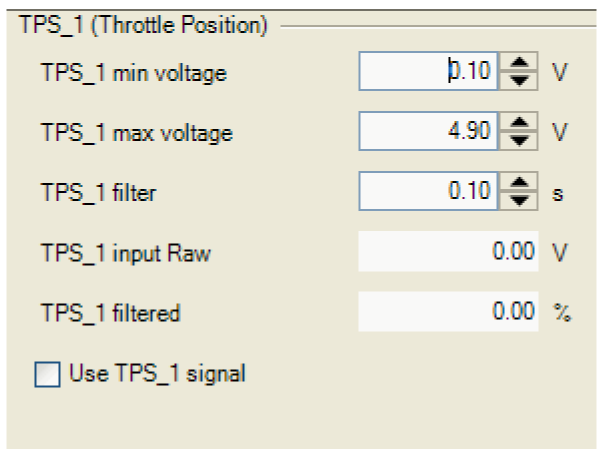


Figure 2-49. FTPS2 Signal Configuration

Use FTPS_2 signal: Enables the FTPS2 functionality.
FTPS_2 min voltage: The alarm threshold value for the low voltage diagnostic. Defaults 0.10 V.
FTPS_2 max voltage: The alarm threshold value for the high voltage diagnostic. Default is 4.9 V.
FTPS_2 filter: Filter that can be entered to filter noise from the input signal.
Upon signal failure the FTPS2 input will be set to zero.

4.1 INPUT (MAP1 / MAP2 / LUBE OIL PRESSURE)

This sets the scaling for the MAP1/2 and lube oil pressure sensor (if used). The MAP2 settings will only appear if “STEREO ENGINE” is selected.

MAP_1-signal

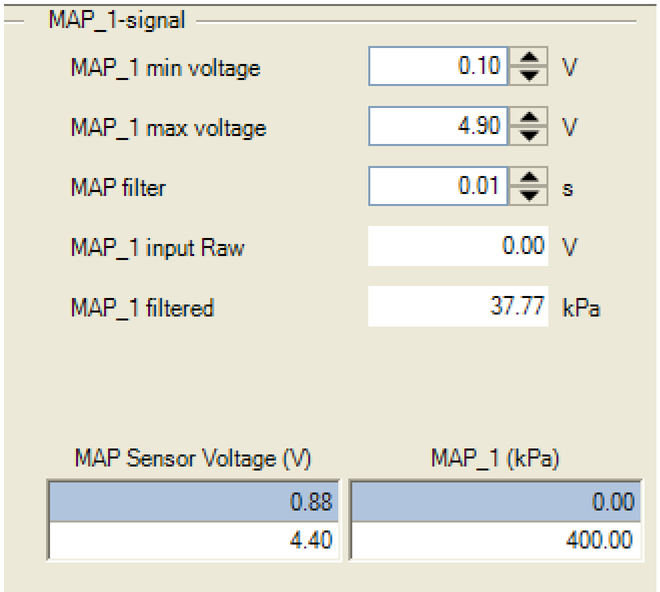


Figure 2-50. MAP1 Signal Configuration

In the table the input voltage versus the MAP transfer function is configured. Also a filter time constant can be entered to filter noise from the input signal.

The default calibration is (for Woodward part number 6910-314 MAP sensor):
0.0 V – 1.11 kPa
5.0 V – 315.28 kPa

The alarm thresholds are adjusted in the upper two fields. The default value for low voltage alarm threshold is 0.1 V and for the high voltage alarm threshold is 4.9 V. If the sensor voltage is out of range, this will result in an alarm or engine shutdown, depending on configuration.

MAP_2-signal

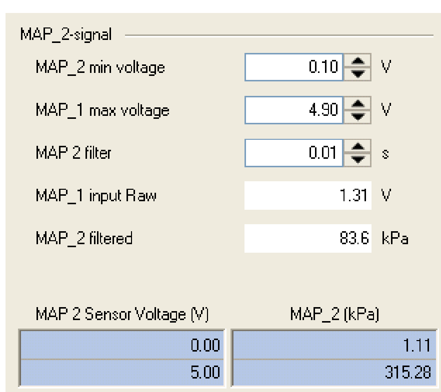


Figure 2-51. MAP2 Signal Configuration

In the table the input voltage versus the MAP transfer function is configured. Also a filter time constant can be entered to filter noise from the input signal.

The default calibration is (for Woodward part number 6910-314 MAP sensor):
0.0 V – 1.11 kPa
5.0 V – 315.28 kPa

The alarm thresholds are adjusted in the upper two fields. The default value for low voltage alarm threshold is 0.1 V and for the high voltage alarm threshold is 4.9 V. If the sensor voltage is out of range, this will result in an alarm or engine shutdown, depending on configuration.

Lube Oil Pressure-signal

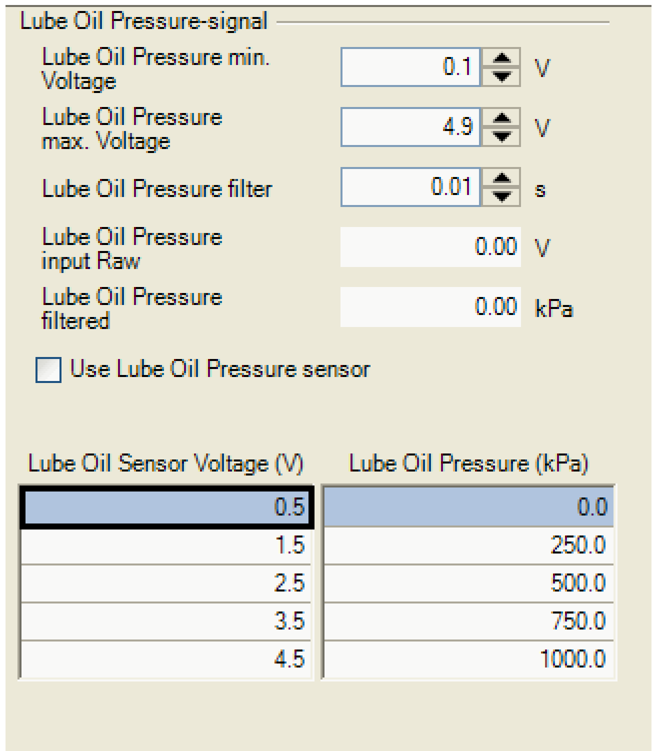


Figure 2-52. LOP Signal Configuration

In the table the input voltage versus the LOP transfer function is configured. Also a filter time constant can be entered to filter noise from the input signal.

The alarm thresholds are adjusted in the upper two fields. The default value for low voltage alarm threshold is 0.1 V and for the high voltage alarm threshold is 4.9 V. If the sensor voltage is out of range, this will result in an alarm or engine shutdown, depending on configuration (see Alarm/Shutdown Configuration in Chapter 4).

4.2- INPUT (BAROMETRIC PRESSURE)

Only used for UEGO Closed Loop systems if using GQCL or open loop control than AL25 should be Overridden (Page 8.3).

The barometric pressure is used to determine the absolute exhaust backpressure. The exhaust backpressure is used as a correction on the UEGO measurement. There is no separate barometric pressure sensor. Instead, the MAP sensor is used to measure the barometric pressure.

When the E3 controller is powered and the key switch input is powered (if used) and engine rotation is not detected by the controller, the MAP sensor signal is recorded. If this value is not between the “BARO low limit” and the “BARO high limit” the alarm for “BARO out of range” will be activated. If the value is between the two limits than that value will be used for the barometric correction on the UEGO sensor.

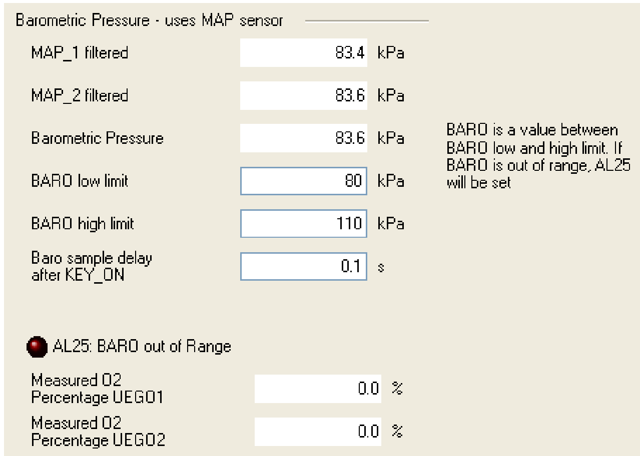


Figure 2-53. BARO using MAP Sensor

BARO low limit: The minimum barometric pressure the system will capture. If the MAP1 sensor is reading below this value after the “BARO sample delay after KEY_ON” the AL25 will become active and the system will use this value for the barometric pressure.
BARO high limit: The maximum barometric pressure the system will capture. If the MAP1 sensor is reading above this value after the “BARO sample delay after KEY_ON” the AL25 will become active and the system will use this value for the barometric pressure.
BARO sample delay after KEY_ON: The time delay after KEY_ON becomes true before the control captures the MAP1 reading to use for the barometric pressure. This value may need to be increased based on the response time of the MAP sensor being used. For systems that always have the “KEY_ON” powered when the E3 is powered extending this value to 1 second or greater can help eliminate nuisance alarms.

4.3- INPUT (EBP1 / EBP2)

The E3 system uses the exhaust backpressure (EBP) curve to compensate the UEGO sensors’ response to exhaust pressure variation. These tables should be populated with actual exhaust backpressure measured values.

Figure 2-54. HMI Settings Exhaust Backpressure 1/2

4.4- INPUT (MAT1 / MAT2)

Manifold Air temperature (MAT) measurements are used by the control to maintain consistent air fuel ratio control independent of the MAT. Typically environmental conditions will significantly impact the manifold temperature and this in turn affects the charge air temperature. Lowering the charge air temperature will result in lower NOx emissions for a given Lambda/GQCL set point and the air fuel ratio set point should be adjusted accordingly to ensure the NOx values remain consistent independent of environmental influences.

MAT_1

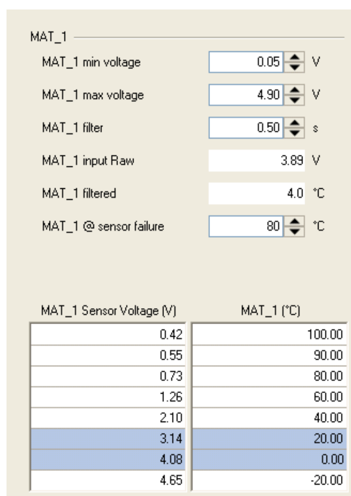


Figure 2-55. MAT1 Signal Configuration

MAT_1 min voltage: Minimum voltage on the input before a failed sensor low fault is annunciated.
MAT_1 max voltage: Maximum voltage on the input before a failed sensor high fault is annunciated.
MAT_1 filter: Filter time constant to filter noise from the input signal.
MAT_1@sensor failure: When a faulted sensor is diagnosed (see figure above) the system will use this value to allow the engine to continue to run.

The voltage-to-temperature transfer function table is adjusted by the user. The sensor type is NTC (negative temperature coefficient), i.e. as temperature increases, the resistance decreases.

The alarm thresholds are adjusted in the upper two fields. The default value for low alarm threshold is 0.05 V and for the high alarm threshold is 4.9 V. If the sensor voltage is outside the alarm threshold, the temperature entered at "MAT @ sensor failure" will be used.

MAT_1 Calibration
Note that the sensor works as a resistor in a voltage dividing circuit inside the E3 control hardware.

The correct voltage as a function of temperature can be calculated with the following formula:

$$\left(Voltage\_at\_EGS\_input = \frac{Rthermistor}{Rthermistor + 2210} * 5V\right)$$

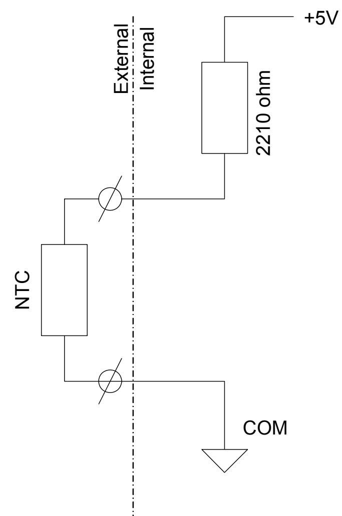


Figure 2-56. Analog Input Circuit – Resistance Temperature Sensors

The calibration for the Woodward MAT sensor DL08041301 is given in the table below and shown graphically.

Ohm	Temp °C	Voltage at E3 Input
204	100	0.42
275	90	0.55
376	80	0.73
526	70	0.96
746	60	1.26
1081	50	1.64
1598	40	2.10
2417	30	2.61
3717	20	3.14
5969	10	3.65
9795	0	4.08
29124	-20	4.65

If a sensor with a different transfer function is used, the transfer function table should be adjusted accordingly.

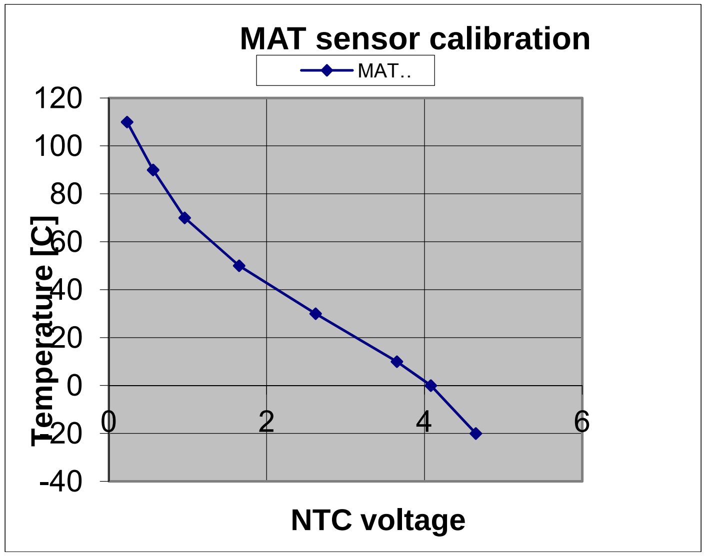
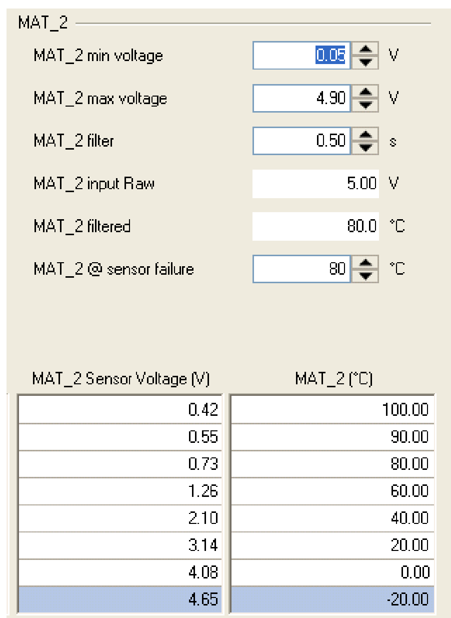


Figure 2-57. MAT Sensor Calibration

MAT_2



MAT_2 min voltage: Minimum voltage on the input before a failed sensor low fault is annunciated.
MAT_2 max voltage: Maximum voltage on the input before a failed sensor high fault is annunciated.
MAT_2 filter: Filter time constant to filter noise from the input signal.
MAT_2@sensor failure: When a faulted sensor is diagnosed (see figure above) the system will use this value to allow the engine to continue to run.

MAT_2 Calibration
Note that the sensor works as a resistor in a voltage dividing circuit inside the E3 control hardware.

The correct voltage as a function of temperature can be calculated with the following formula:

$$\left(Voltage\_at\_EGS\_input = \frac{Rthermistor}{Rthermistor + 2210} * 5V\right)$$

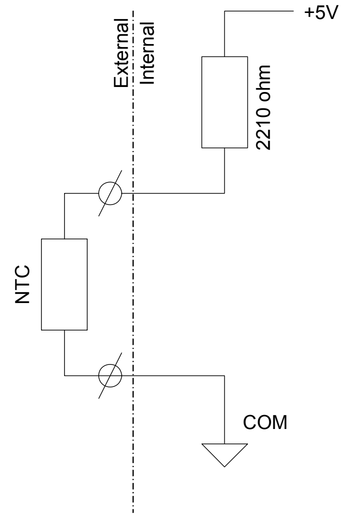


Figure 2-58. Analog Input Circuit – Resistance Temperature Sensors

The calibration for the Woodward MAT sensor DL08041301 is given in the table below and shown graphically.

Ohm	Temp °C	Voltage at E3 Input
204	100	0.42
275	90	0.55
376	80	0.73
526	70	0.96
746	60	1.26
1081	50	1.64
1598	40	2.10
2417	30	2.61
3717	20	3.14
5969	10	3.65
9795	0	4.08
29124	-20	4.65

If a sensor with a different transfer function is used, the transfer function table should be adjusted accordingly.

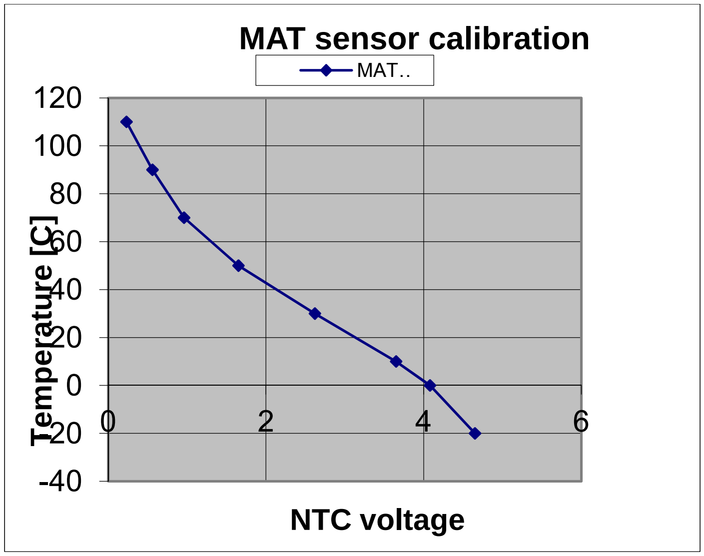


Figure 2-59. MAT Sensor Calibration

4.5- INPUT (ECT)

The engine coolant temperature (ECT) sensor can be used to:

1. Alter the open loop table trim valve commands to richen the engine on cold starts.
2. Used to de-rate the engine.
3. Used to adjust the inlet air temperature used for Lambda offsets

The input is identical to the ones used for MAT ½ and the same sensor DL08041301 can be used, with the default settings preconfigured for this sensor.

ECT

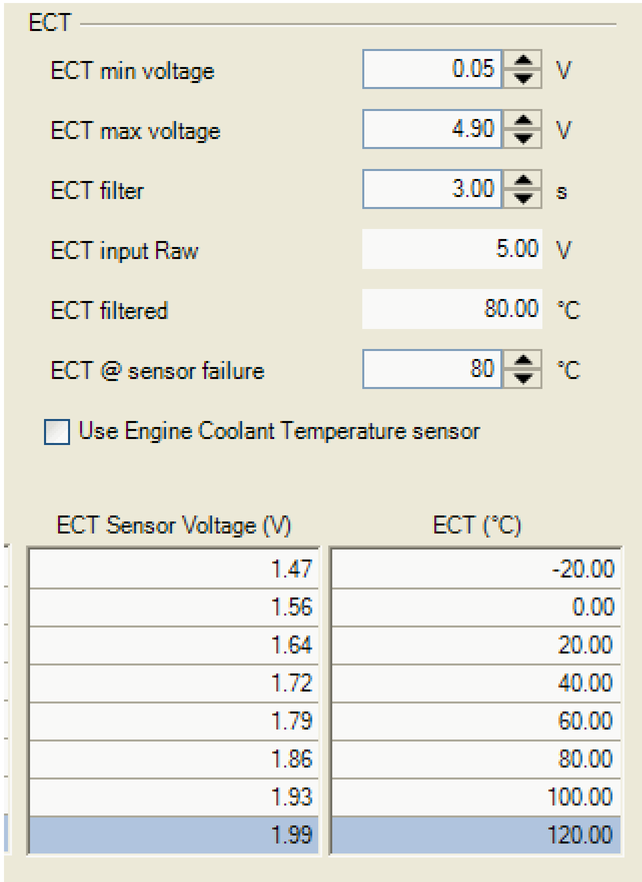


Figure 2-60. ECT Signal Configuration

ECT min voltage: Minimum voltage on the input before a failed sensor low fault is annunciated.
ECT max voltage: Maximum voltage on the input before a failed sensor high fault is annunciated.
ECT filter: Filter time constant to filter noise from the input signal.
ECT @sensor failure: When a faulted sensor is diagnosed (see figure above) the system will use this value to allow the engine to continue to run.

ECT Calibration
Note that the sensor works as a resistor in a voltage dividing circuit inside the E3 control hardware.

The voltage to temperature transfer function table is adjusted by the user. The input is designed to work with 0 to 5 Volt signals and requires a resistor type sensor connected to ground. The sensor type is NTC (negative temperature coefficient), i.e. as temperature increases, the resistance decreases. Note that the sensor works as a resistor in a voltage dividing circuit inside the PCM128-HD. The correct voltage as a function of temperature can be calculated with the following formula:

$$\left(Voltage\_at\_EGS\_input = \frac{Rthermistor}{Rthermistor + 2210} * 5V\right)$$

The calibration for the Woodward MAT sensor DL08041301 is given in the table below.

Ohms	Temp °C	Voltage at E3 Input
204	100	0.42
275	90	0.55
376	80	0.73
526	70	0.96
746	60	1.26
1081	50	1.64
1598	40	2.10
2417	30	2.61
3717	20	3.14
5969	10	3.65
9795	0	4.08
29124	-20	4.65

If a sensor with a different transfer function is used, the transfer function table (see Figure 2-61) should be adjusted accordingly.

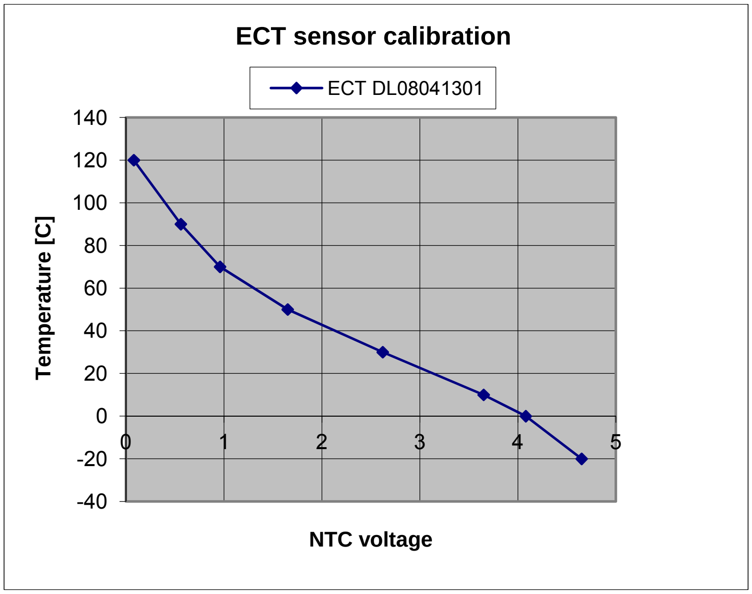


Figure 2-61. ECT Sensor Voltage vs. Temperature (°C)

The alarm thresholds are adjusted in the upper two fields. The default value for low alarm threshold is 0.05 V and for the high alarm threshold is 4.9 V. If the sensor voltage is outside the alarm threshold, the temperature entered at “ECT @ sensor failure” will be used.

The ECT sensor is optional. If an ECT sensor is not used, ECT is calculated using MAT, the user entered value “ECT @ sensor failure”, and the warm-up time. When the engine is running, the calculated ECT is linearly increased from MAT to the “ECT @ sensor failure”, during the warm-up time. When the engine stops, the calculated ECT is reduced back to MAT over the warm-up time. The recommended value for “ECT @ sensor failure” is the normal expected jacket water temperature for a fully warmed up engine.

4.6- INPUT (MAT1 vs. IAT2 / MAT2 vs. IAT2)

In normal operation, there are differences between the manifold mixture temperature (the measured MAT) and the actual mixture temperature as it enters the cylinders (the Inlet Air Temperature – IAT). This is caused by heat transfer to the intake charge due to contact with engine parts that have a coolant temperature-related surface temperature, such as the cylinder head intake ports. Since the temperature will change from the measured MAT, a correction is needed to get an accurate approximation of IAT.

There is a selection between a calculation of IAT or a manually entered transfer function table.

By default the calculation is selected

If the ECT is not measured (not used, or ECT sensor voltage out of range), it is estimated from “ECT @sensor failure” and the warm-up time

The ECT estimation is done using the MAT, the reference temperature (ECT @ sensor failure) and the warm-up time. When the engine is running, the estimated ECT is linearly increased from MAT to the reference temperature, during the warm-up time. When the engine stops, the estimated ECT is reduced back to MAT over the warm-up time. The estimated ECT is then used instead of measured ECT, to determine IAT.

MAT vs. Inlet Common Values

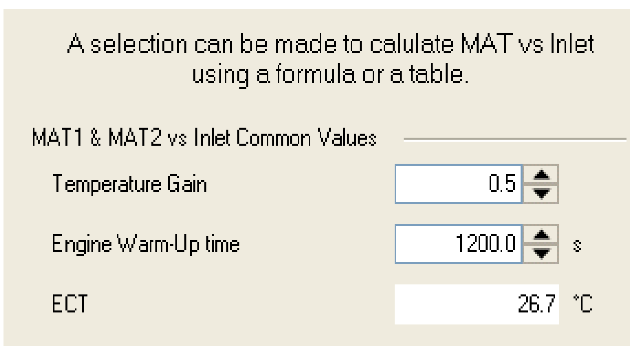


Figure 2-62. MAT vs. Inlet Common Values

Temperature Gain (Calculated Load Only): Sets the temperature gain factor based on ECT and MAT measurement.

Engine Warm-Up time: Time for cranking until unit is up to nominal temperature. If an ECT sensor is not used this would be the time it takes for the unit to come up to “ECT @sensor failure”

Temp.Gain = 0	IAT = MAT
Temp.Gain = 1	IAT = ECT

MAT1 vs. IAT1

The end user can select from the calculation or a manually entered table.

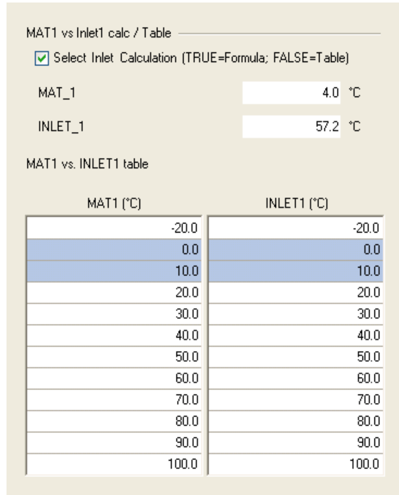


Figure 2-63. Settings for MAT1 vs. Inlet 1

MAT2 vs. IAT2

The end user can select from the calculation or a manually entered table.

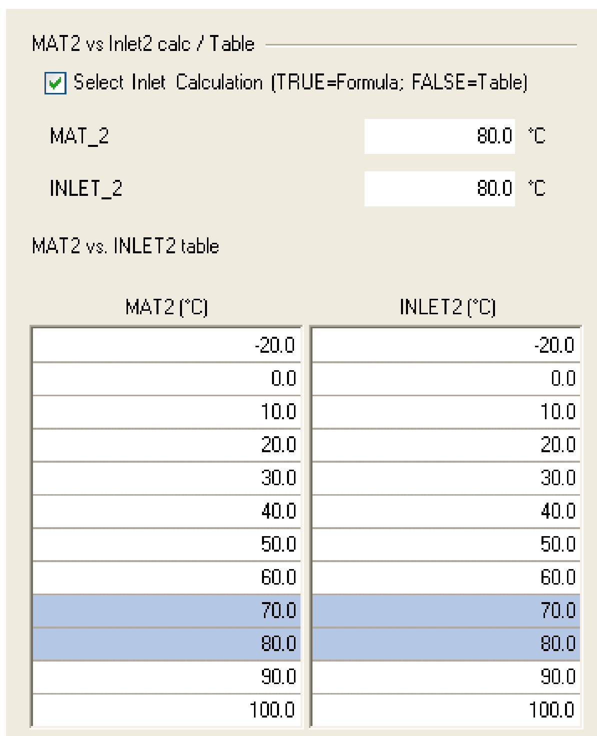


Figure 2-64. Settings for MAT2 vs. Inlet 2

4.7- INPUT (REMOTE REF/SPD BIAS)

Analog (0–5 Vdc) inputs from generator controls. These values are not needed if a Woodward easYgen-3xxx is connected over CAN.

Remote Speed/Load Reference Input—This input can be used for either a remote speed reference input or a remote load reference input. The remote speed reference input could be used in a variable speed application when you want to set the engine speed from a remote location with an analog signal (it could also be done with the raise and lower speed contact inputs). The remote load reference input could be used when the E3 is controlling generator load when parallel with the grid. The input voltage range should be set in accordance with the plant signal. The allowable input voltage is 0 to 5 V. In the table at the bottom the input voltage versus the Speed/Load percentage transfer function is configured. This specifies the conversion of the input signal voltage to percent.

The default calibration is:
0.5 V – (0 % of the speed limit range) + Lower Speed limit
4.5 V – (100 % of the speed limit range) + Lower Speed limit

The speed limit range is calculated as follows:
Raise Speed limit – Lower Speed limit = Speed range
These limits also apply to the discrete input raise and lower speed limits.

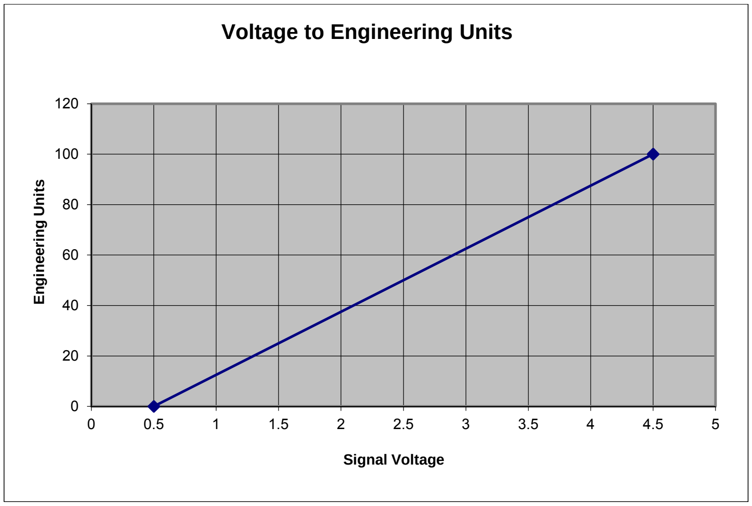


Figure 2-65. Input voltage to Engineering Units

NOTICE	**The input should be galvanically isolated from external voltage signals to avoid ground loops and incorrect readings.**

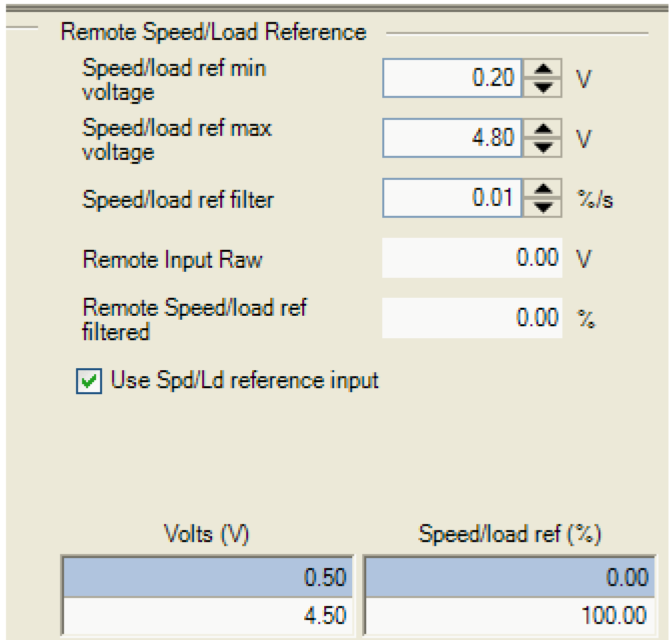


Figure 2-66. Remote Speed/Load Reference Signal Configuration

Speed/load ref min/ voltage: The low value for a failed input signal. Default 0.2 Vdc
Speed/load ref max/ voltage: The high value for a failed input signal. Default 4.8 Vdc.
These alarms are automatically enabled when option “Use Spd/Ld reference input” is “Checked”.
Speed/Load Ref filter: Filter that can be tuned to filter noise from the input signal.
Use Spd/Ld reference input: Check box that when “Checked” enables the function.

Upon signal failure the Remote reference input will hold the last value. This value is used until a valid signal is re-established.

Speed Bias Input
The voltage to speed bias transfer function table is adjusted by the user. The input is designed to work with 0 to 5 V signals

The default calibration for the bias is:
0.5 V – -20 rpm
4.5 V – +20 rpm

The alarm thresholds are adjusted in the upper two fields. The default value for low alarm threshold is 0.20 V and for the high alarm threshold is 4.8 V. To enable the alarms the “Use Speed Bias input” checkbox needs to be selected. When this checkbox is unselected the bias is forced to 0 rpm.

A filter time constant (“Speed Bias filter”) can be entered to filter noise from the input signal.

NOTICE	**The input should be galvanically isolated from external voltage signals to avoid ground loops and wrong indications.**

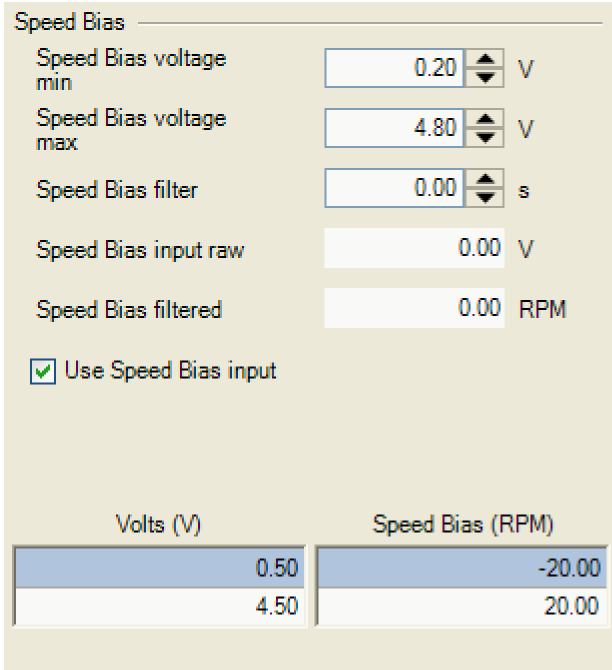


Figure 2-67. Speed Bias Signal Configuration

Speed Bias voltage min: The low value for a failed input signal. Default 0.2 Vdc
Speed Bias voltage max: The high value for a failed input signal. Default 4.8 Vdc. These alarms are automatically enabled when option “Use Speed Bias input” is “Checked”.
Speed Bias filter: Filter that can be tuned to filter noise from the input signal.
“Use Speed Bias input: Check box that when “Checked” enables the function.

Upon signal failure the Speed Bias input will be set to zero.

4.8- INPUT (DIGITAL INPUTS)

All digital inputs are relative to XDRG_A and XDRG_B.

Use External SD
There are four digital inputs used for optional external shutdown. These inputs can be configured as N.O. (normally open) or N.C. (normally closed) input. It is highly recommended that these be used in their default, N.C. configuration only, for fail safe operation.

If the application is for a pump or compressor the shutdowns can be configured as soft shutdown. With a soft shutdown the speed reference will ramp down at the user specified raise/lower speed rate to the user specified minimum speed and then shutdown; the shutdown output will be activated.

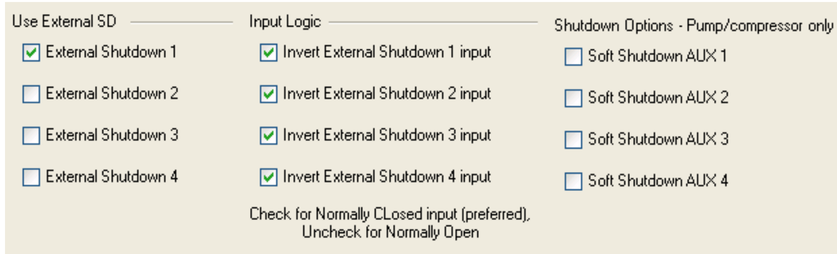


Figure 2-68. External Shutdown Configuration

External Shutdown 1: Checking this box will enable Shutdown 1 on input J1-B07 when it is connected to J1-A24.
Invert External Shutdown 1 input: When the box is checked the input is a normally closed input (preferred), when it is unchecked it is a normally open input.
Soft Shutdown AUX1: With a soft shutdown the speed reference will ramp down at the user specified raise/lower speed rate to the user specified minimum speed and then shutdown; the Shutdown output and logic will be then be activated. (Pump/Compressor mode only)

External Shutdown 2: Checking this box will enable Shutdown 2 on input J1-C16 when it is connected to J1-A24.
Invert External Shutdown 2 input: When the box is checked the input is a normally closed input (preferred), when it is unchecked it is a normally open input.
Soft Shutdown AUX2: With a soft shutdown the speed reference will ramp down at the user specified raise/lower speed rate to the user specified minimum speed and then shutdown; the Shutdown output and logic will be then be activated. (Pump/Compressor mode only)

External Shutdown 3: Checking this box will enable Shutdown 3 on input J1-A19 when it is connected to J1-A24.
Invert External Shutdown 3 input: When the box is checked the input is a normally closed input (preferred), when it is unchecked it is a normally open input.
Soft Shutdown AUX3: With a soft shutdown the speed reference will ramp down at the user specified raise/lower speed rate to the user specified minimum speed and then shutdown; the Shutdown output and logic will be then be activated. (Pump/Compressor mode only)

External Shutdown 4: Checking this box will enable Shutdown 4 on input J1-A09 when it is connected to J1-A24.
Invert External Shutdown 4 input: When the box is checked the input is a normally closed input (preferred), when it is unchecked it is a normally open input.
Soft Shutdown AUX4: With a soft shutdown the speed reference will ramp down at the user specified raise/lower speed rate to the user specified minimum speed and then shutdown; the Shutdown output and logic will be then be activated. (Pump/Compressor mode only)

Digital Inputs-Key Switch
Green indicates key switched on. There is no user configuration of this function. If a key switch is not used, this input should be powered whenever the system is powered.

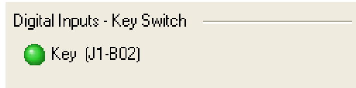
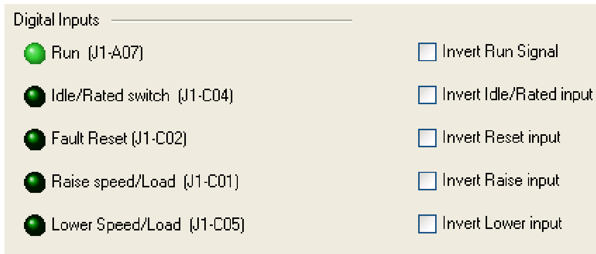


Figure 2-69. Digital Inputs-Key Switch

Digital Inputs



Run: Green indicates that the contact is "True" relative to the connection of J1-A07 to J1-A24. When this input is active, and engine rotation is detected by the controller, the following will occur:

- gas shutoff valve output is energized (after purge time has expired)
- mixture throttle position command is enabled
- trim valve position command is enabled
- If Smart Coils are used, the spark outputs are enabled.

Invert Run Signal: The logic can be user adjusted to configure the input as a N.O. or N.C. input. Unchecked is Normally Closed (preferred), and checked is Normally Open.

Idle/Rated switch: Green indicates that this contact is active relative to the connection of J1-C04 to J1-A24 and the speed reference will remain at "Minimum Speed ref/Idle". The input can be configured as a N.O. or N.C. input.
Invert Idle/Rated Input: The logic can be user adjusted to configure the input as a N.O. or N.C. input. Unchecked is Normally Closed (preferred), and checked is Normally Open.

Fault Reset: Reset indicates the reset contact is active relative to the connection of J1-C02 to J1-A24. This input is used to clear alarms and shutdowns. The input can be configured as a N.O. or N.C. input.
Invert Fault Rest: The logic can be user adjusted to configure the input as a N.O. or N.C. input. Unchecked is Normally Closed (preferred), and checked is Normally Open.

Raise Speed/Load: Green indicates that this contact is active relative to the connection of J1-C01 to J1-A24. The speed or load set point is raised in accordance with the applicable user specified rate (see *Speed Reference* and *Load Control (Grid Mode) Reference* in Chapter 2).
Invert Raise Speed/Load: The logic can be user adjusted to configure the input as a N.O. or N.C. input. Unchecked is Normally Closed (preferred), and checked is Normally Open.

Lower Speed/Load: Green indicates that this contact is active relative to the connection of J1-A07 to J1-C05. The speed or load set point is lowered in accordance with the applicable user specified rate.
Invert Lower Speed/Load: The logic can be user adjusted to configure the input as a N.O. or N.C. input. Unchecked is Normally Closed (preferred), and checked is Normally Open.

Digital Inputs – Generator

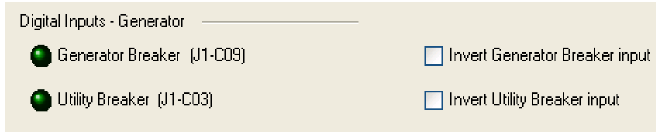


Figure 2-70. Digital Inputs - Generator

Generator Breaker: Green indicates that the generator breaker is closed relative to the connection of J1-A07 to J1-C09.
Invert Generator Breaker Input: The logic can be user adjusted to configure the input as a N.O. or N.C. input. Unchecked is Normally Closed (preferred), and checked is Normally Open.
Utility Breaker Green indicates that the utility breaker is closed relative to the connection of J1-C03 to J1-A24.
Invert Utility Breaker input: The logic can be user adjusted to configure the input as a N.O. or N.C. input. Unchecked is Normally Closed (preferred), and checked is Normally Open.

Digital Inputs – Level Switches

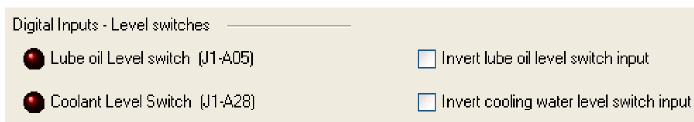


Figure 2-71. Digital Inputs – Level Switches

Cooling Water Level switch
Cooling water level switch Red indicates that this contact is active relative to the connection of J1-A07 to J1-A28 signifying that the sensed cooling water level is low.
Invert Cooling Water Level switch: The logic can be user adjusted to configure the input as a N.O. or N.C. input. Unchecked is Normally Closed (preferred), and checked is Normally Open.

Lube Oil Level switch: Red indicates that this contact is active relative to the connection of J1-A07 to J1-A28 signifying that the sensed oil level is low.

In the default configuration, this input is only monitored when the engine is stopped. This is intended for engines whose oil level may be below the sensor during normal operation. If the lube oil level alarm function is desired when the engine is running as well, please contact Woodward.
Invert Lube Oil Level Switch input: The logic can be user adjusted to configure the input as a N.O. or N.C. input. Unchecked is Normally Closed (preferred), and checked is Normally Open.

4.9- INPUT (SPEED SENSORS)

Speed Sensing

The actual speed of the engine needs to be accurately measured whether the E3 is doing Speed control or just AFR control. The speed signal is used for the AFR setpoints and for the sequencing of the position of the actuators. To do this the raw speed signal enters the software as a frequency and is converted into engine speed (rpm) based on Woodward developed algorithms that eliminate the torsional components of the signal that come from the discrete combustion events.

The E3 system features a selection of different speed signal patterns to cover different engine configurations.

Most parameters related to the speed pattern configuration are only when updated after the control is rebooted. To ensure that the values entered by the end user of in use the settings are in an “Offline Editor” button. That will automatically take the end user to the offline settings editor page where the values can be updated and the service tool will automatically reboot the controller after prompting from the user.

Adjust Speed Sensor Configuration in Offline Editor: Takes user to offline editor where the parameters can be adjusted and will take effect after the user commands a reboot of the controller by pressing “Apply” or “OK” in the offline editor.

Speed Patterns
In order to provide engine synchronous spark trigger outputs (i.e. when Smart Coils are used in the system), the E3 controller must be able to correctly determine engine position. This is accomplished by placing sensors on the cam and crank of the engine that sense the passing of teeth or voids. Each time a tooth (or void) passes the sensor, the E3 controller updates the calculated engine speed and position. The user must select the pattern from the options below that matches the engine configuration. If Smart Coils are used, Pattern 2 or Pattern 3 must be selected and correctly configured. If Smart Coils are not used, Pattern 1 should be selected.

The speed sensing is performed using the pattern selected on this screen. The different pattern options allow selection of the appropriate speed sensing pattern for the engine and ignition configuration.

- Pattern 1 – Redundant evenly spaced—Select when no Smart Coils are used.
- Pattern 2 – N crank & 1 cam—Select when Smart Coils are used on an engine with a single tooth cam sensor wheel.
- Pattern 3 – N crank & 6+1 (advance) cam—Select when Smart Coils are used on an engine with a 6+1 advanced tooth cam sensor wheel. The PCM128-HD SPD1 input is used for the crank sensor when using this pattern.

Changes to the speed sensor input settings are only are recognized by the control only after a power cycle. The pattern can only be changed with the engine stopped. The pattern can be changed and then saved, after which the power to the control needs to be cycled to implement the change.

The speed filter time constant can be specified by the user. E.g., if tuning of the speed dynamics is proving difficult, this filter can be tuned to potentially give better performance.

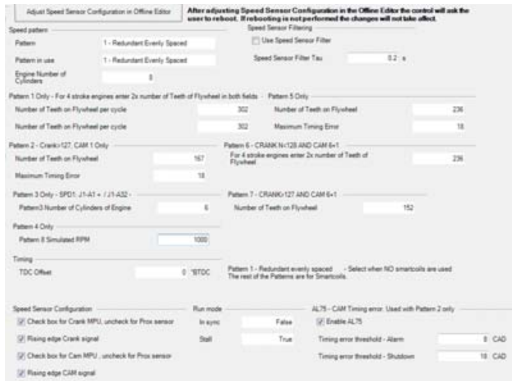


Figure 2-72. Speed Pattern Configuration

The engine must be shutdown before rebooting.
Pattern: Pattern used for speed sensing (1-7)

1. Redundant evenly spaced teeth
2. N crank and 1 tooth on cam, where N=number of cylinders
3. N+1 where N=number of teeth on crank plus one extra tooth in advance of TDC of cylinder 1

Number of Cylinders: This is the number of cylinders on the engine and is used to filter out firing torsionals.

Pattern "1 - Redundant Evenly Spaced"
This is an evenly spaced speed-sensing pattern. Either the cam input only or both the crank and cam inputs of the E3 controller be can be used, but in the latter case both are used to redundantly sense crankshaft speed. This pattern does not provide any engine synchronizing information and will not support spark triggering.

The maximum MPU frequency should be limited to 6375 Hz or 3000 Crank RPMs, whichever is less. If this limit is exceeded, the pulses will be interpreted as noise and therefore ignored. The speed will be read as 0 RPM.

Number of Teeth on Flywheel per cycle: This needs to be the number of teeth on the flywheel that pass the speed pickup per cycle. On a 4-stroke engine this will 2x the number of teeth on the crank.
Number of Teeth on Flywheel per cycle: This needs to the same as the number entered in the previous tunable. If these numbers do not match the control will always read “0” speed. It needs to be the number of teeth on the flywheel that pass the speed pickup per cycle. On a 4-stroke engine this will 2x the number of teeth on the crank.

Pattern "2 - Crank>127, CAM 1"
This pattern uses pickups on the CAM and CRANK. The crank trigger wheel consists of N evenly spaced teeth. The number of teeth on the crank trigger wheel can be from 128 to 510. The cam trigger wheel consists of a single tooth. Synchronization is achieved on the first crank tooth after the cam tooth. This is crank tooth #1

Number of Teeth on Flywheel: This needs to be the number of teeth on the flywheel that pass the speed pickup per revolution.

CAM timing error (Used with Pattern 2, 5 only)
Use of this function provides alarm and shutdown protection in case of a discrepancy between the sensing of teeth by the cam sensor versus the crank sensor. When crank tooth counts are high, the lash between the measured cam and crank tooth positions can be significant. This may cause sensing of the cam tooth to not always occur between the same two crank teeth. Therefore a user-input value is used to specify the absolute value of the maximum expected cam tooth sensed position variation relative to the crankshaft in degrees. For example, if the cam pulse is expected to shift in the advanced direction from crank tooth 1 by a maximum of 10.0 degrees, then 10.0 degrees should be entered in this field. The pattern software will be configured to allow the cam pulse to shift by 10.0 degrees in either the advanced or retarded direction without interruption in sync status or timing. This value, in degrees, will be converted to number of teeth, rounding down to the nearest tooth. Therefore the user should be aware that 10.0 degrees entered in this field may not correspond to the full 10.0 degrees because it depends on the degrees per tooth of the trigger wheel.

To configure this function, in the box next to “Timing error threshold – Alarm”, the user should enter the measured error, in degrees, to trigger an alarm. In the box next to “Timing error threshold – Shutdown”, the user should enter the measured error, in degrees, to trigger a shutdown. These values, in degrees, will be converted to number of teeth, rounding down to the nearest tooth.

To enable this function, the box next to “Enable AL75” must be checked.

Pattern "3 - N+1 CAM"N Evenly Spaced Tooth Crank, Cam N Plus One, Advanced Tooth

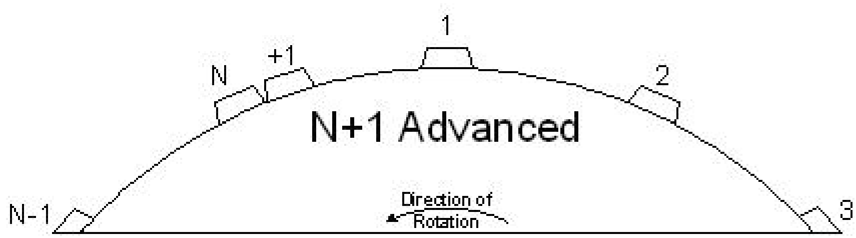


Figure 2-73. Pattern 3

This pattern uses a pickup on the CAM sensor for engine synchronization, as well as a crank pickup for speed sensing. The frequency range for the crank input is 0–12 kHz. The cam wheel must have 6 evenly spaced teeth with the addition of a single tooth. The extra tooth must be located such that it is 1/4 of the way between Tooth 6 and Tooth #1. Stated another way, if the time between Tooth #6 and the extra tooth is greater than 1/3 the time between Tooth #5 and Tooth #6 there will be a fault generated.
Tooth number 1 constitutes the 0 degree reference.

Pattern "4 - RPM Simulation"
This is a diagnostic mode that generates a RPM equal to “Pattern 8 Simulated RPM” (default 1000 rpm). It will fire the sparks, injectors, and all other engine related inputs as if it was synced to a real pattern at the specified RPM.

If a wheel pattern different from the above options is desired, please contact Woodward.

Pattern "5 - Crank<128, CAM 1"
This pattern uses pickups on the CAM and CRANK. The crank trigger wheel consists of N evenly spaced teeth. The number of teeth on the crank trigger wheel can be from 30 to 127. The cam trigger wheel consists of a single tooth. Synchronization is achieved on the first crank tooth after the cam tooth. This is crank tooth #1

Number of Teeth on Flywheel: This needs to be the number of teeth on the flywheel that pass the speed pickup per revolution.

CAM timing error (Used with Pattern 2, 5 only)
Use of this function provides alarm and shutdown protection in case of a discrepancy between the sensing of teeth by the cam sensor versus the crank sensor. When crank tooth counts are high, the lash between the measured cam and crank tooth positions can be significant. This may cause sensing of the cam tooth to not always occur between the same two crank teeth. Therefore a user-input value is used to specify the absolute value of the maximum expected cam tooth sensed position variation relative to the crankshaft in degrees. For example, if the cam pulse is expected to shift in the advanced direction from crank tooth 1 by a maximum of 10.0 degrees, then 10.0 degrees should be entered in this field. The pattern software will be configured to allow the cam pulse to shift by 10.0 degrees in either the advanced or retarded direction without interruption in sync status or timing. This value, in degrees, will be converted to number of teeth, rounding down to the nearest tooth. Therefore the user should be aware that 10.0 degrees entered in this field may not correspond to the full 10.0 degrees because it depends on the degrees per tooth of the trigger wheel.

To configure this function, in the box next to “Timing error threshold – Alarm”, the user should enter the measured error, in degrees, to trigger an alarm. In the box next to “Timing error threshold – Shutdown”, the user should enter the measured error, in degrees, to trigger a shutdown. These values, in degrees, will be converted to number of teeth, rounding down to the nearest tooth.

To enable this function, the box next to “Enable AL75” must be checked.

Pattern "6 - CRANK N<128 AND CAM 6+1"
This pattern uses pickups on the CAM and CRANK. The crank trigger wheel consists of N evenly spaced teeth with no gaps. The number of teeth on the crank trigger wheel can be from 30 to 127. On the Cam there are 6 evenly spaced teeth with the addition of a single tooth. The tooth must be centered such that the extra tooth is 1/4-1/3 of the way between Tooth M and Tooth #1. More precisely, the period between the +1 tooth and tooth 1 must be greater than the period between tooth 6 and the +1 tooth. This means that a +1 tooth moved more than 50% of the distance from the 6 tooth to tooth #1 will cause a cam fault. The period between the +1 tooth and tooth 6 must be less than half the period between tooth 6-1 and tooth 6. In all other cases, the current period must be greater than half the previous period. If these rules are violated, there will be a cam fault.

Sync is achieved on the first crank tooth after cam tooth #1. This is crank tooth #1.

If the cam signal is not present for more than 1 engine cycle, then CAM_FLT will be set.

The “Number of Teeth on Flywheel” must be 2x the number of the teeth on the flywheel for 4 stroke engines and have 4-254 entered when using this pattern.

Pattern "7 - CRANK>127 AND CAM 6+1"
This pattern uses pickups on the CAM and CRANK. The crank trigger wheel consists of N evenly spaced teeth with no gaps. The number of teeth on the crank trigger wheel can be from 127 to 254. On the Cam there are M evenly spaced teeth with the addition of a single tooth. The tooth must be centered such that the extra tooth is 1/4-1/3 of the way between Tooth M and Tooth #1. More precisely, the period between the +1 tooth and tooth 1 must be greater than the period between tooth M and the +1 tooth. This means that a +1 tooth moved more than 50% of the distance from the M tooth to tooth #1 will cause a cam fault. The period between the +1 tooth and tooth M must be less than half the period between tooth M-1 and tooth M. In all other cases, the current period must be greater than half the previous period. If these rules are violated, there will be a cam fault.

Sync is achieved on the first crank tooth after cam tooth #1. This is crank tooth #1.

If the cam signal is not present for more than 1 engine cycle, then CAM_FLT will be set.

The “Number of Teeth on Flywheel” must be the number of the teeth on the flywheel for 4 stroke engines and have 4-254 entered when using this pattern.

Speed Sensor Filtering

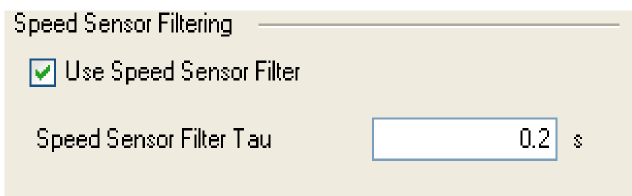


Figure 2-74. Speed Sensor Filtering

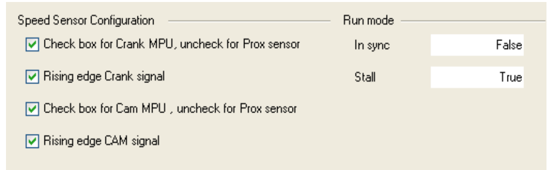
Use Speed Sensor: If this is selected the “Speed Sensor Filter Tau” will filter the speed used to create the speed signal used by the control. If this is un-checked only the torsional filter based on the number of cylinders on the engine will be used.

Speed Sensor Filter TAU:
This speed signal is filtered with a second order filter, with a tunable filter time constant. This tunable value has a range of 0.0 (unfiltered) to 10 seconds and a default of 0.016 seconds (a frequency of 10 Hz). The filter relationships with frequency and time are given below.

$$f = \frac{1}{2\pi T} \qquad T = \frac{1}{2\pi f}$$

Filtering should be kept to a minimum to minimize lag, i.e. the time constant should be as small as possible.

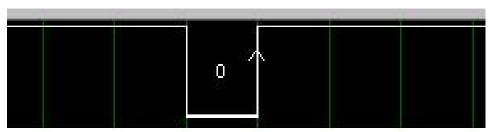
Speed Sensor Configuration



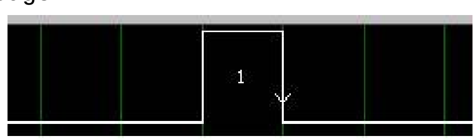
Check box for Crank MPU, uncheck for Prox sensor: The crank signal can use either an MPU or a Prox (active pickup). On units with large run out and/or slow cranking speeds a Prox probe may be preferred.
Rising edge Crank Signal: Adjusts between a rising edge crank signal (default) or a falling edge
Check box for Cam MPU, uncheck for Prox sensor: The CAM signal can use either an MPU or a Prox (active pickup and preferred).
Rising edge CAM signal: Adjusts between a rising edge crank signal (default) or a falling edge

For the noise rejection to work properly the cam edge should be selected such that it is the trailing edge of the pulse.

If your cam pulse looks like the following, the CAM_EDGE should be set for RISING edge:



If your cam pulse looks like the following, the CAM_EDGE should be set for FALLING edge:



Speed Sensor Signal Configuration

If the relationship between the cam pulse and cylinder #1 TDC is not positively known for the engine being commissioned, the following procedure or equivalent is recommended to establish the correct offset. The box beside “TDC Offset” should be set to 0 for this procedure. An oscilloscope should be employed with the cam signal connected to channel 1. Be sure that the signal to the oscilloscope is the same polarity as the signal going to the E3 controller. A current probe should be placed on wire to Smart Coil # 1 pin E and connected to channel 2. The engine should then be cranked with the fuel supply disabled while recording data. It will require several revolutions for the E3 controller to “sync up” before the Smart Coil begins to operate. Simultaneously with recording the oscilloscope data, “Ignition Advance Total” should be observed and/or recorded using the HMI. Alternatively, since the engine will not be started during this test, the spark timing settings can be configured to ensure a constant timing advance (e.g. 0º BTDC).

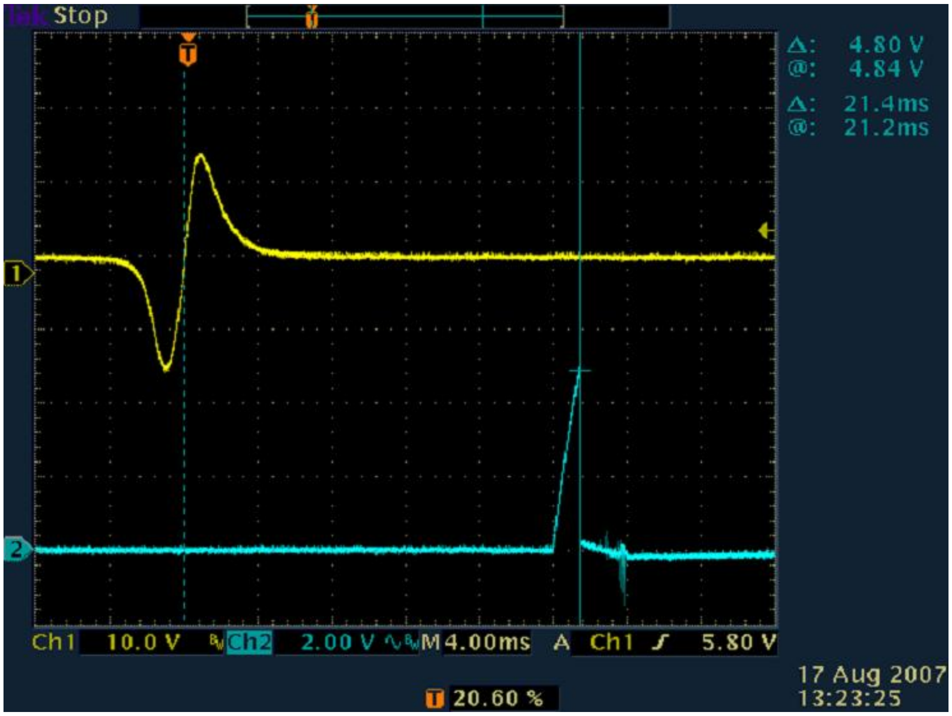


Figure 2-75. Oscilloscope Data for establishing CAM TDC offset.

The following is an example of calculating the TDC offset based on oscilloscope data (see Figure 4-10 for reference).

Speed (rpm)	800	calculate from time between cam pulses – zero crossing to zero crossing
Delta T (s)	0.0214	measure from cam pulse zero crossing to Smart Coil probe falling edge
Delta CAD	102.72	= Delta T * Speed/60 * 360 degrees
Cyl Timing	10.28	"Ignition Advance Total" from HMI during test
Index to TDC	113	= Delta CAD + Cyl Timing

4.10- INPUT (LOAD SENSOR)

Analog input from kW transducer or generator control. This value is not needed if a Woodward easYgen-3xxx is connected over CAN.

The engine load can be measured with a load sensor in a generator application. The load sensor is required when GQCL mode is selected.

In the table the input voltage versus load (kW) transfer function is configured. Also a filter time constant ("Load filter") can be entered to filter noise from the input signal.

The default calibration is:
0.5 V – 0 kW
4.5 V – 1300 kW

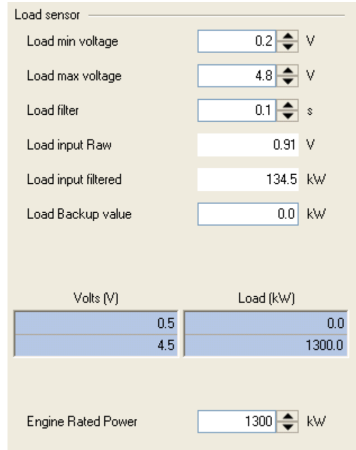


Figure 2-76. kW Sensor Signal Configuration

Load min voltage: The low value for a failed input signal. Default 0.2 Vdc
Load *max voltage*: The high value for a failed input signal. Default 4.8 Vdc.
Load Filter: Filter that can be tuned to filter noise from the input signal.
Load Backup value: A user entered constant that is used by the logic if the voltage sensed at the load sensor input is outside the user specified min - to max voltage limits.
Engine Rated Power: This is the rated electrical power of the engine/generator combination.

4.11- BOSCH UEGO 1 HEATER

The E3 Lean Burn Trim system uses the Bosch LSU 4.2 UEGO sensor (Woodward part number 1689-1032). For complete information on this sensor, see *Bosch LSU 4.2 Sensor Application Manual*, document no. 26345 (to obtain a copy, please contact Woodward).
The UEGO sensor measures the amount of oxygen in the exhaust gas. This measurement is then used to calculate the air/fuel ratio.

If the system will be used in lambda closed loop mode, the UEGO sensor is installed permanently. In GQCL mode, if an exhaust gas analyzer is not available for initial calibration, the system can optionally be calibrated with a UEGO sensor, which is installed for GQCL calibration only.

Condensation Protection
The UEGO sensing element is susceptible to damage from thermal shock caused by impingement of water droplets while the heater element is on. This is most likely to occur shortly after startup of a cold engine, due to water vapor (produced by combustion) condensing inside the cold exhaust pipe work. During this period the heater power must remain off, to prevent thermal shock damage to the sensor ceramic element. The delay before heater power is enabled following engine startup is based on the Engine Coolant temperature (ECT) at startup. If the ECT signal is out of range or not used, the “Delay at ECT sensor failure” time is used.

When the ECT signal is valid, the delay time used is the longer of the corresponding interpolated value from the table and the Woodward delay time, e.g.:

Woodward delay time	: 60 s
ECT 70 °C	: 30 s
Delay	: 60 s

The UEGO condensation protection settings should only be adjusted by trained and authorized personnel.

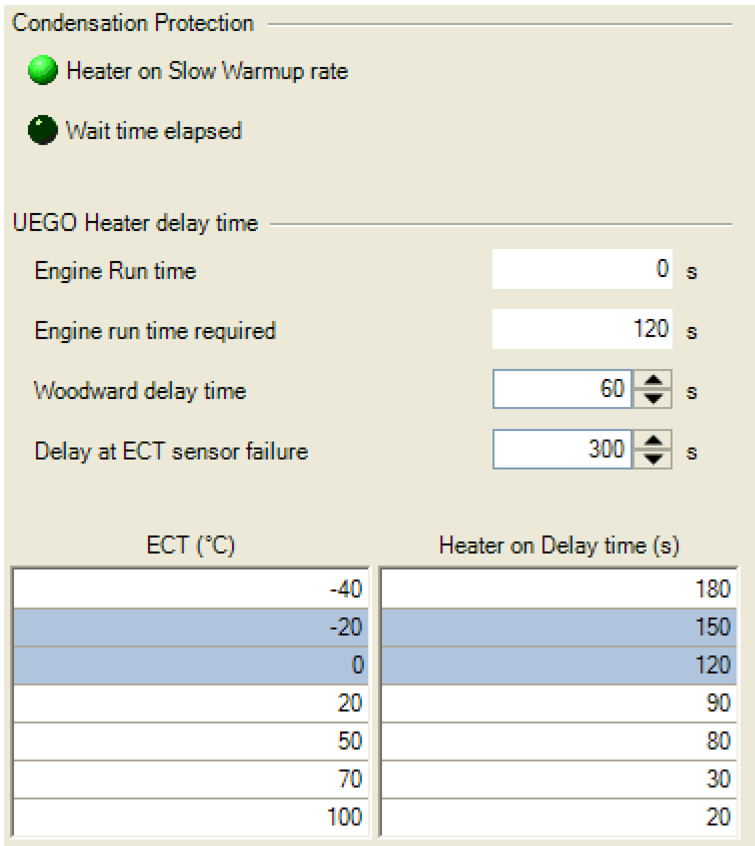


Figure 2-77. UEGO Condensation Protection Settings

UEGO Sensor Air Calibration

In use, the UEGO sensor signal can shift, due to aging and/or contamination. The UEGO Sensor Air Calibration feature allows the user to check and adjust a UEGO sensor signal that may have shifted.

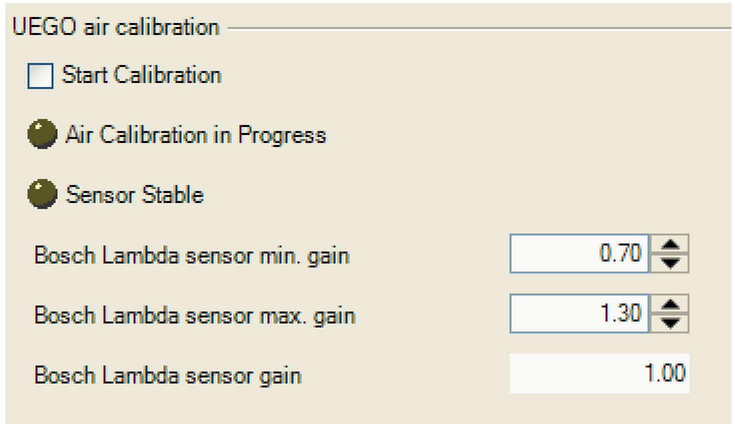


Figure 2-78. UEGO Air Calibration

The UEGO Sensor Air Calibration is accomplished by performing the following steps:

1. Remove the UEGO sensor from the exhaust system; leave the UEGO sensor hanging in ambient air and switch on the controller.
2. Check the box beside "Start Calibration". The "Air Calibration in Progress" LED will light. During this process the sensor is heated to operating temperature and then the pump current in ambient air is compared to the expected value. The sensor gain is then adjusted by the E3 controller to achieve the correct pump current.
3. Wait until the "Sensor Stable" LED lights, indicating the gain adjustment was successful. This adjustment will be stored in the E3 until the next air calibration is performed. A sensor gain value between 0.99 and 1.07 is considered normal for a new sensor. With age the sensor may drift outside these values.
4. Uncheck the box beside "Start Calibration".
5. Save Values and switch off the controller.
6. Allow the UEGO sensor time to cool down before handling. When safe to handle, reinstall the UEGO sensor in the exhaust system.

4.12- BOSCH UEGO 1 SENSOR

The UEGO sensor has a special circuit on the controller to measure the signals. Measurement of the oxygen as it relates to Lambda and heater control are all done internally to the control software. The sensor element temperature is constantly monitored, and kept at 750 °C by the closed loop heater logic.

The UEGO sensor settings rarely need adjustment and typically the only action and end user needs to take is to do periodic "Air Calibrations." Otherwise the settings should only be adjusted by trained and authorized personnel.

Bosch Sensor

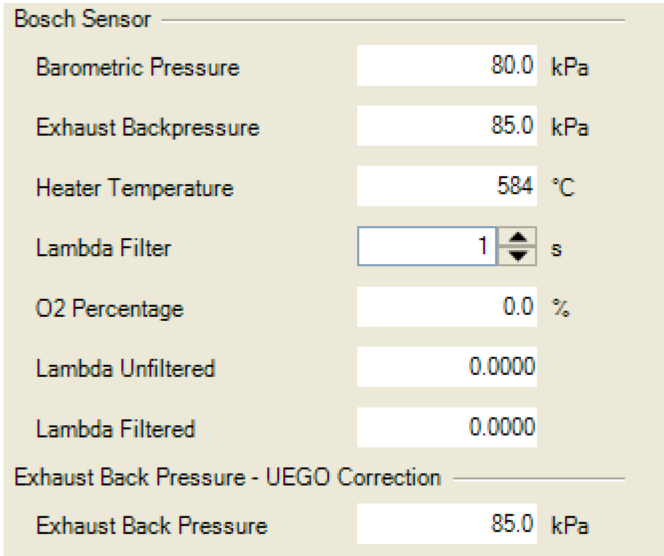
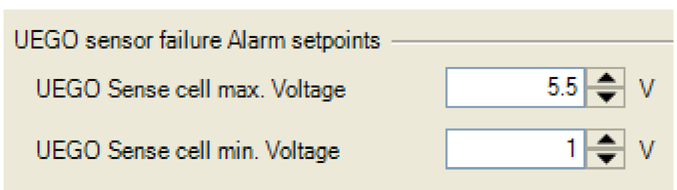


Figure 2-79. Bosch UEGO Sensor Settings

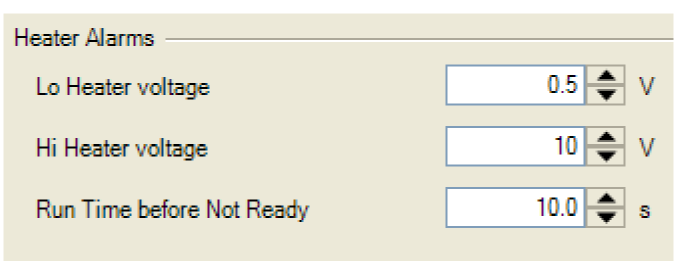
Lambda Filter: A filter that allows the user to filter the Lambda signal.

UEGO Sensor failure Alarm Setpoints
Fault thresholds are adjustable for the cell voltage and heater voltage.



UEGO Sense cell max. Voltage: Any sense cell voltage above this value will create a fault. The default voltage high alarm threshold is 5.5 V
UEGO Sense cell min. Voltage: Any sense cell voltage below this value will create a fault. The default value for sense cell voltage low alarm threshold is 1.0 V.

Heater Alarms



Lo Heater voltage: Any heater voltage below this value will create a fault. The default threshold is 0.5 V.
Hi Heater voltage: Any heater voltage above this value will create a fault. The default threshold is 10 V.
Run Time before Not Ready: delays the alarm until the time entered has elapsed.

4.13- BOSCH UEGO 2 HEATER

The E3 Lean Burn Trim system uses the Bosch LSU 4.2 UEGO sensor (Woodward part number 1689-1032). For complete information on this sensor, see *Bosch LSU 4.2 Sensor Application Manual*, document no. 26345 (to obtain a copy, please contact Woodward).
The UEGO sensor measures the amount of oxygen in the exhaust gas. This measurement is then used to calculate the air/fuel ratio.

If the system will be used in lambda closed loop mode, the UEGO sensor is installed permanently. In GQCL mode, if an exhaust gas analyzer is not available for initial calibration, the system can optionally be calibrated with a UEGO sensor, which is installed for GQCL calibration only.

Condensation Protection
The UEGO sensing element is susceptible to damage from thermal shock caused by impingement of water droplets while the heater element is on. This is most likely to occur shortly after startup of a cold engine, due to water vapor (produced by combustion) condensing inside the cold exhaust pipe work. During this period the heater power must remain off, to prevent thermal shock damage to the sensor ceramic element. The delay before heater power is enabled following engine startup is based on the Engine Coolant temperature (ECT) at startup. If the ECT signal is out of range or not used, the “Delay at ECT sensor failure” time is used.

When the ECT signal is valid, the delay time used is the longer of the corresponding interpolated value from the table and the Woodward delay time, e.g.:

Woodward delay time	: 60 s
ECT 70 °C	: 30 s
Delay	: 60 s

The UEGO condensation protection settings should only be adjusted by trained and authorized personnel.

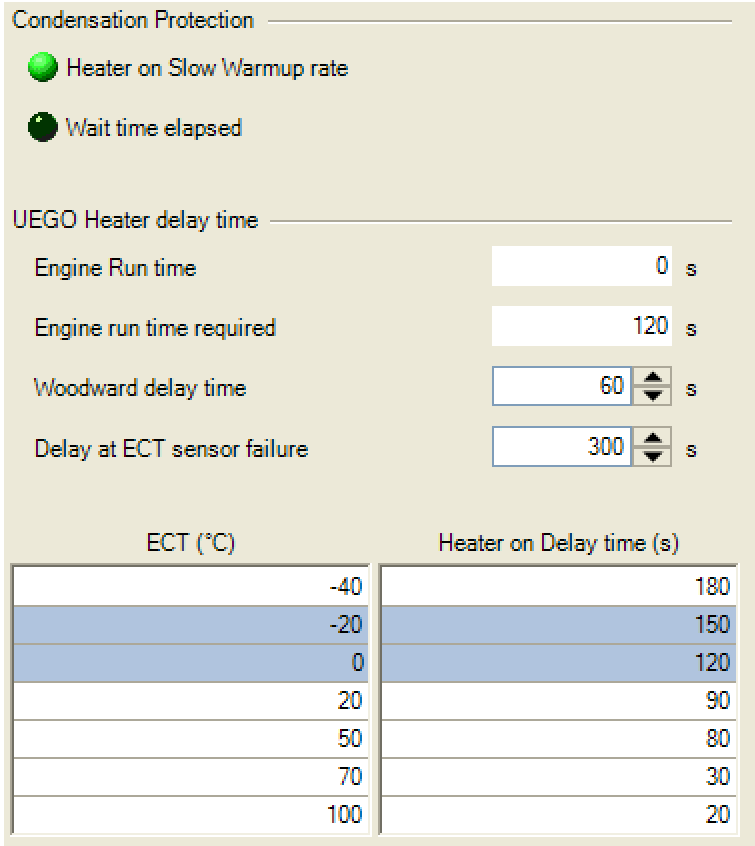


Figure 2-80. UEGO Condensation Protection Settings

UEGO Sensor Air Calibration
In use, the UEGO sensor signal can shift, due to aging and/or contamination. The UEGO Sensor Air Calibration feature allows the user to check and adjust a UEGO sensor signal that may have shifted.

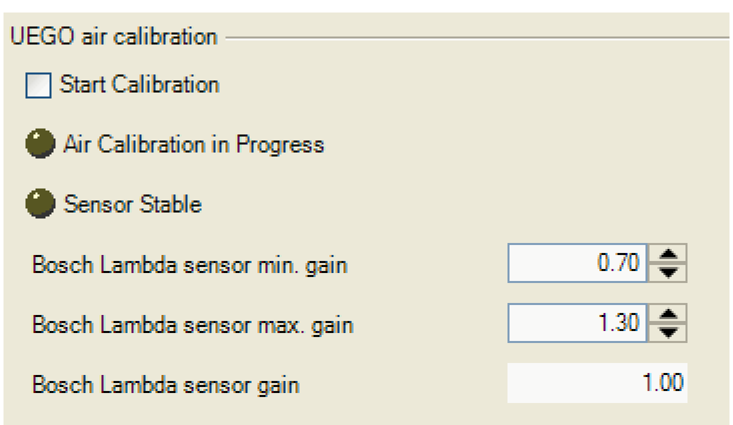


Figure 2-81. UEGO Air Calibration

The UEGO Sensor Air Calibration is accomplished by performing the following steps:

7. Remove the UEGO sensor from the exhaust system; leave the UEGO sensor hanging in ambient air and switch on the controller.
8. Check the box beside “Start Calibration”. The “Air Calibration in Progress” LED will light. During this process the sensor is heated to operating temperature and then the pump current in ambient air is compared to the expected value. The sensor gain is then adjusted by the E3 controller to achieve the correct pump current.
9. Wait until the “Sensor Stable” LED lights, indicating the gain adjustment was successful. This adjustment will be stored in the E3 until the next air calibration is performed. A sensor gain value between 0.99 and 1.07 is considered normal for a new sensor. With age the sensor may drift outside these values.
10. Uncheck the box beside “Start Calibration”.
11. Save Values and switch off the controller.
12. Allow the UEGO sensor time to cool down before handling. When safe to handle, reinstall the UEGO sensor in the exhaust system.

4.14- BOSCH UEGO 2 SENSOR

The UEGO sensor has a special circuit on the controller to measure the signals. Measurement of the oxygen as it relates to Lambda and heater control are all done internally to the control software. The sensor element temperature is constantly monitored, and kept at 750 °C by the closed loop heater logic.

The UEGO sensor settings rarely need adjustment and typically the only action and end user needs to take is to do periodic “Air Calibrations.” Otherwise the settings should only be adjusted by trained and authorized personnel.

Bosch Sensor

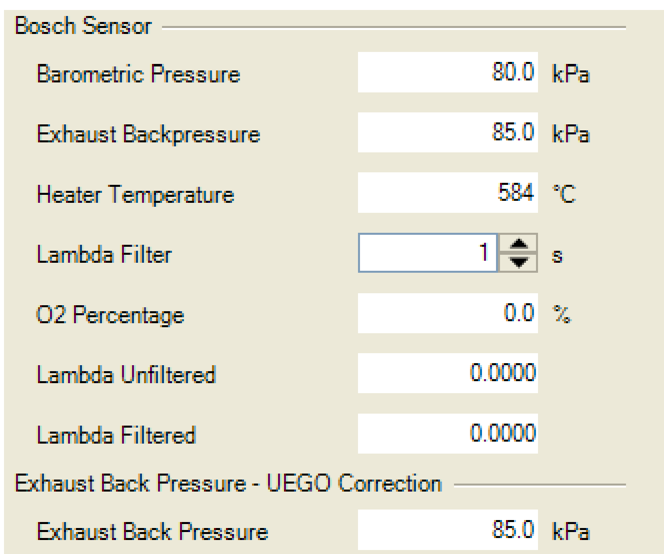
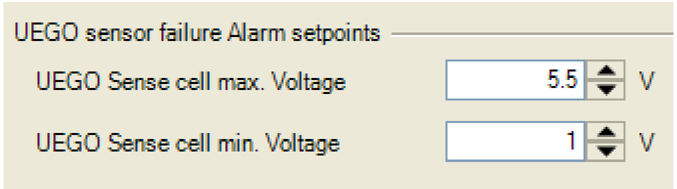


Figure 2-82. Bosch UEGO Sensor Settings

Lambda Filter: A filter that allows the user to filter the Lambda signal.

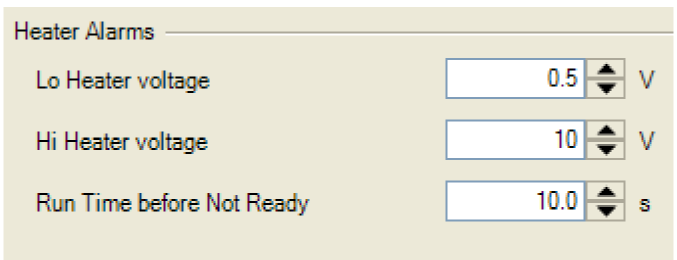
UEGO Sensor failure Alarm Setpoints

Fault thresholds are adjustable for the cell voltage and heater voltage.



UEGO Sense cell max. Voltage: Any sense cell voltage above this value will create a fault. The default voltage high alarm threshold is 5.5 V
UEGO Sense cell min. Voltage: Any sense cell voltage below this value will create a fault. The default value for sense cell voltage low alarm threshold is 1.0 V.

Heater Alarms



Lo Heater voltage: Any heater voltage below this value will create a fault. The default threshold is 0.5 V.
Hi Heater voltage: Any heater voltage above this value will create a fault. The default threshold is 10 V.
Run Time before Not Ready: delays the alarm until the time entered has elapsed.

4.15- easYgen

The E3 Lean Burn Trim system can be configured to receive speed or load control signals from the easYgen-3XXX Power Management modules. The easYgen-3XXX is connected to the external (plant) J1939 communication bus to integrate it with the E3 System. Complete information on installation, configuration, and operation of the easYgen can be found in documents 37223, 37224 and 37225.

Control and diagnostic information between the units is exchanged via this bus connection,

When the box under “Setup” is checked the E3 will ignore the hard wired input for load, breakers, and speed/load bias.

When the box beside “Allow easYgen to Stop the engine” is checked, the E3 controller will obey commands from the easYgen to shutdown the engine.

The speed bias signal (±100%) received from the easYgen is converted to ± rpm by the user specified “Maximum speed deviation +/–”.

Figure 2-83. easYgen-3XXX HMI settings

5.1 MISFIRE

Global misfire detection based on instantaneous crank angle velocity (ICAV) measurement has the capability of detecting persistent misfire of any cylinder. The individual misfiring cylinder is not identified. The Misfire Detection system monitors the irregularity of the engine speed, which has a regular pattern corresponding to cylinder combustion events.

When the engine speed irregularity exceeds the user-calibrated level during the user calibrated period a fault will be activated. Deviation from the regular pattern, which generally causes an increase in the irregularity, can be due to failures in the ignition system like spark plugs, coils, cables, extenders etc. Also a problem with the A/F ratio control, e.g. when the mixture is too lean, can cause a Misfire Detection alarm. Furthermore, engine problems like damaged valves or pistons will increase the level of irregularity.

Knocking combustion or detonation does not produce a significant change in the irregularity of the engine, and will not be detected by the Misfire Detection system.

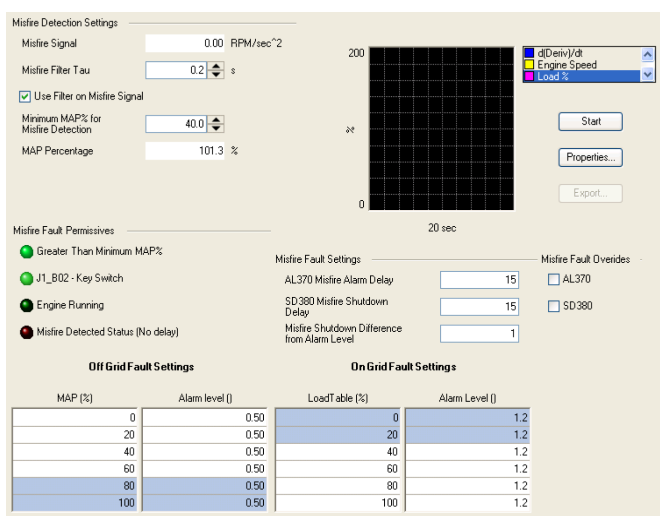


Figure 2-84. Misfire Detection HMI Screen

Misfire Detection Settings
Misfire Signal: The Misfire signal used for fault detection.
Misfire Filter Tau- The misfire signal filter value (sec). Increasing this parameter will smooth the signal but slows response.
Use Filter on Misfire Signal: Check to enable the “Misfire Filter Tau”. Unchecked the raw value from the misfire calculation is used.

Misfire Fault Settings
These settings are duplicates of the settings on the Alarm and Shutdown page, placed here for convenience.

AL370 Misfire Alarm Delay - The delay the misfire condition must stay TRUE before an alarm is activated (sec).
SD380 Misfire Shutdown Delay - The delay the misfire condition must stay TRUE before a shutdown is activated (sec).
Misfire Shutdown Difference from Alarm Level: This setting sets the difference from the alarm level that the misfire signal must reach before SD380 Misfire Shutdown can become true.
For example of the engine is running “Off Grid” and the “Alarm Level” is 0.5 and the Shutdown difference is 1 then a misfire of 1.5 or greater must exist before the SD380 delay timer starts its countdown.

AL370 – Check this box to disable the Misfire Alarm.
SD380 –Check this box to disable the Misfire Shutdown.

Off Grid Fault Settings Table: 2 x 5 lookup table Misfire Index () vs. Alarm Level (RPM/sec^2) allows a non-linear mapping of the fault threshold over the Off Grid (utility breaker open) operating range of the engine.
On Grid Fault Settings: 2 x 5 lookup table Misfire Index () vs. Alarm Level (RPM/sec^2) allows a non-linear mapping of the fault threshold over the operating range of the engine.

Irregularity and Misfire

Normal Irregularity
Reciprocating engines do not have a continuous combustion, in contrast to turbines. The speed of the flywheel changes continuously in accordance with each individual cylinder combustion event. Superimposed on this constant irregularity is the irregularity between successive combustion events, due to the stochastic nature of lean burn gas engine combustion events.

If the engine has no hardware defects and runs with correct A/F ratio and correct spark advance, there will be a certain basic speed irregularity as measured at the flywheel. This basic irregularity is influenced by:

- Number of cylinders, firing order, firing intervals, and cylinder angle (V-engine)
- Inertia of engine and generator
- Stiffness of crankshaft and driveline
- Mode of operation (i.e. parallel to the grid, or island).
- Combustion stability.

Judicious calibration of the misfire detection system during the commissioning of the engine is required for reliable detection of real misfire and to avoid false alarms when there is no misfire.

Misfire Detection Signals
The Misfire Detection system uses a normal inductive speed pick-up that senses the flywheel ring gear teeth. The same signal is used for engine speed control.

The speed signal is processed in such way that only irregularity caused by combustion failures will lead to misfire detection based on the derivative signal. After filtering and peak detection, the processed signal is used to trigger the alarm. During engine commissioning, the goal is to calibrate the alarm levels and the alarm delays of the Misfire Detection system in such a way that no false alarms will be generated.

6.1- IGNITION (Advance)

For IC-920/922 or Smart Coils systems only

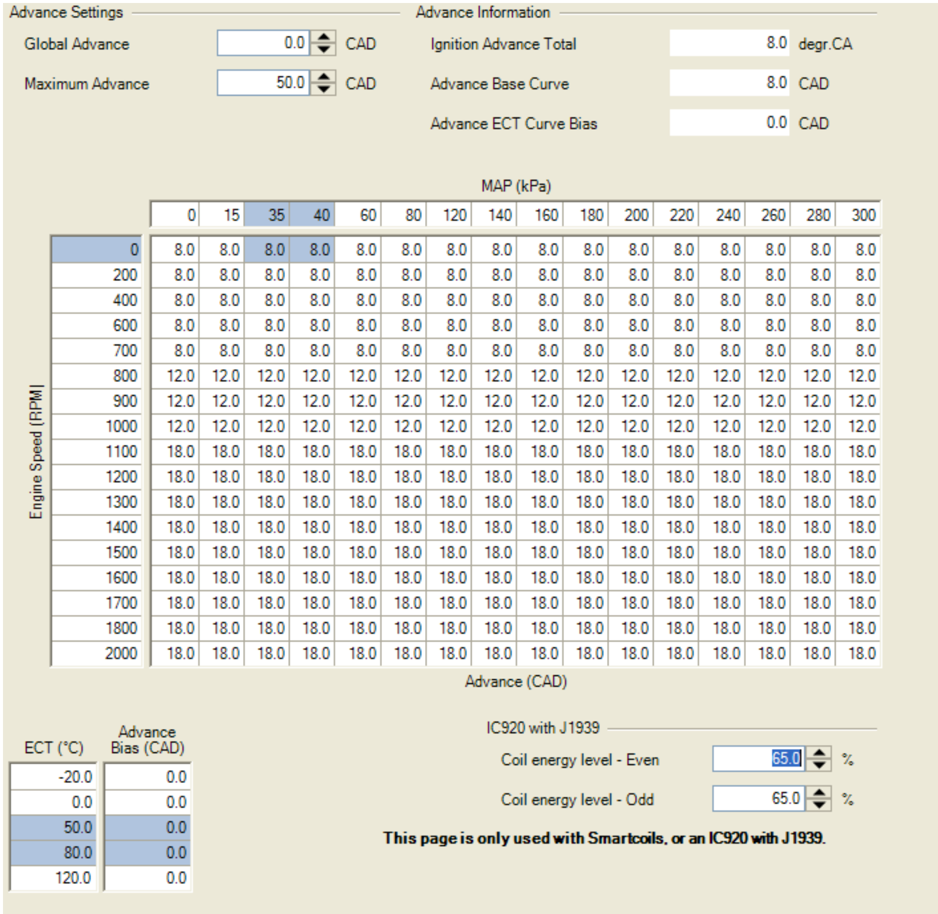
For all timing values: a positive value indicates spark timing in degrees advanced or BTDC; a negative value indicates degrees retarded or ATDC.

The spark timing determination is as follows:

Spark Timing (“Ignition Advance Total” in the control) =
Global Advance+ Advance Base Curve (from speed/load table) + Advance ECT Curve Bias + Knock Timing Retard Offset
Following is a description of these and other parameters used in the ignition subsystem.

Advance Base Curve
This is a 3D curve for adjustment of the timing as a function of speed and load.

Advance ECT Curve Bias
This is a 2D curve for adjustment the timing as a function of engine coolant temperature.



Engine Speed (RPM) \ MAP (kPa)	0	15	35	40	60	80	120	140	160	180	200	220	240	260	280	300
0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
200	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
400	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
600	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
700	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
800	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
900	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
1000	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
1100	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1200	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1300	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1400	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1500	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1600	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1700	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1800	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
2000	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0

ECT (°C)	Advance Bias (CAD)
-20.0	0.0
0.0	0.0
50.0	0.0
80.0	0.0
120.0	0.0

Figure 2-85. HMI Settings for Spark Timing and Coil Energy

TDC Offset
This is a timing offset from the CAM reset signal if this is not on TDC. Figure 2-86 shows the HMI user setting for TDC Offset

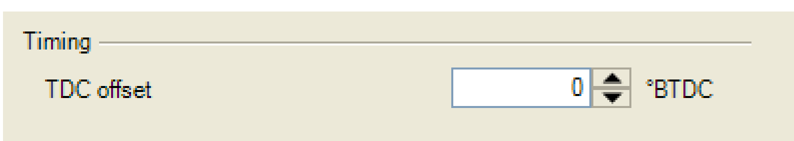


Figure 2-86. HMI Setting for TDC Offset (HMI Screen 4.9)

Ignition Advance Total (Total Timing to Smart Coils/IC-920/922)
As defined above, Total Timing = Global Advance + Advance Base Curve + Advance ECT Curve Bias + Knock timing bias.

Maximum Advance
This is the limit of the Ignition Advance Total.

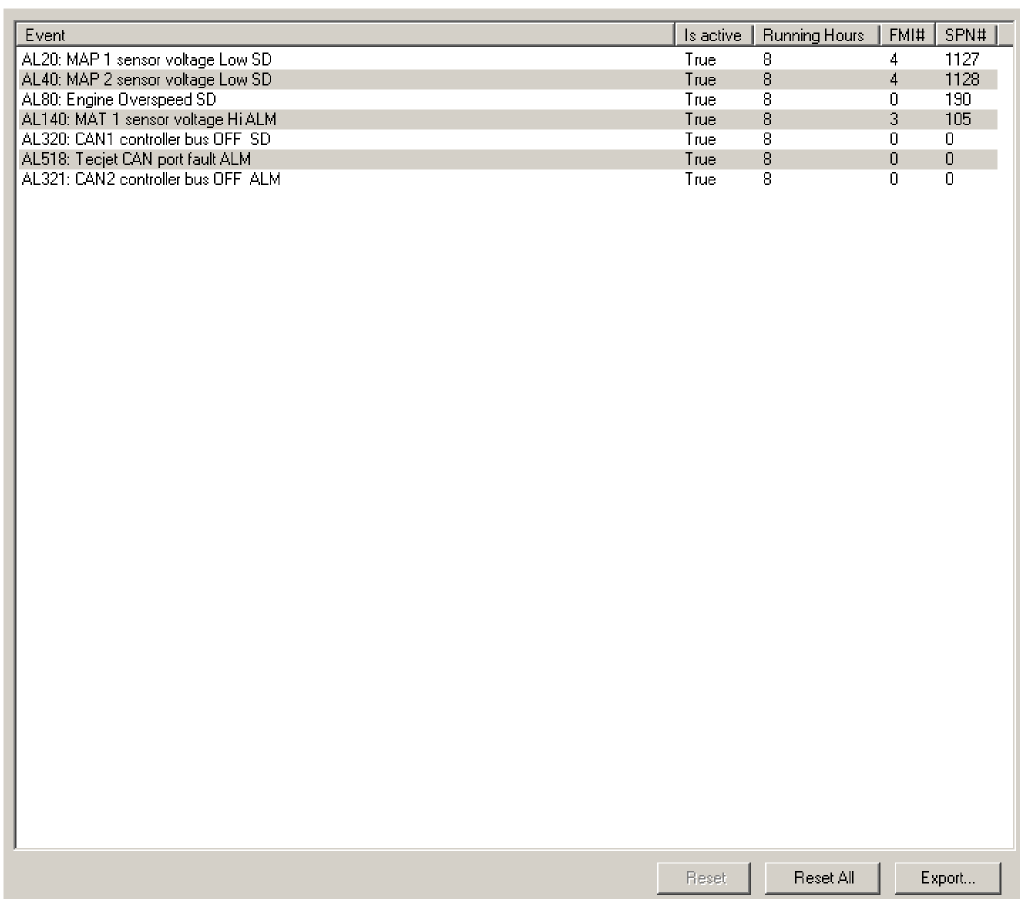
Coil Energy Level (IC-920/922 only)

- Coil Energy Level – Even: The energy level in percentage to the even-numbered cylinders.
- Coil Energy Level – Odd: The energy level in percentage to the odd-numbered cylinders.

7.1 Event List

This list gives an overview of the alarms that are active or have been active in the past. The following columns give relevant information (other columns can be disregarded):

- **Event**
  The alarm ID and description
- **Is active**
  This gives an indication what alarms have happened and are still active in the system or have happened but are not active anymore. When a reset command is given, all the inactive alarms will be cleared.
- **Occurrences**
  the number of times the alarm has occurred since the last reset of the system or the last reset of the event list.
- **Running Hours**
  The time the alarm occurred in running hours
- **FMI#**
  The FMI numbering in the J1939 CAN bus fault detection
- **SPN#**
  The particular fault in the J1939 CAN bus fault detection



Event	Is active	Running Hours	FMI#	SPN#
AL20: MAP 1 sensor voltage Low SD	True	8	4	1127
AL40: MAP 2 sensor voltage Low SD	True	8	4	1128
AL80: Engine Overspeed SD	True	8	0	190
AL140: MAT 1 sensor voltage Hi ALM	True	8	3	105
AL320: CAN1 controller bus OFF SD	True	8	0	0
AL518: Tecjet CAN port fault ALM	True	8	0	0
AL321: CAN2 controller bus OFF ALM	True	8	0	0

Figure 2-87. HMI Event List

The Reset button at the bottom of the screen can be used to clear a specified alarm from the event list. When the Reset All button is clicked, the whole event list will be cleared. It will only clear the alarms in the HMI event list, not the actual alarms stored in the control memory.

Resetting the control via the discrete input or the “Reset Alarms / SD” checkbox on all HMI screens will clear the inactive alarms in the control and from the event list.

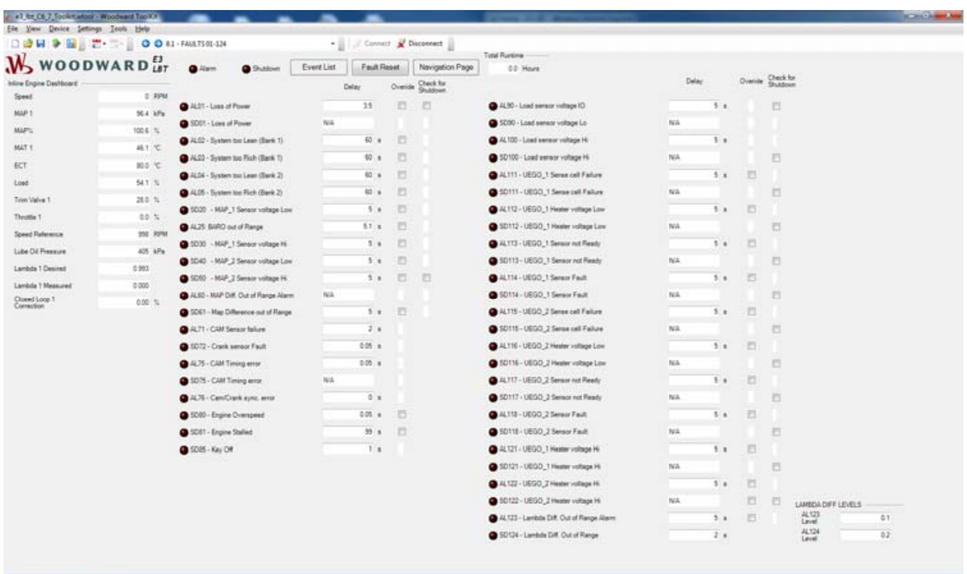
Engine Protection

Alarm/Shutdown Configuration

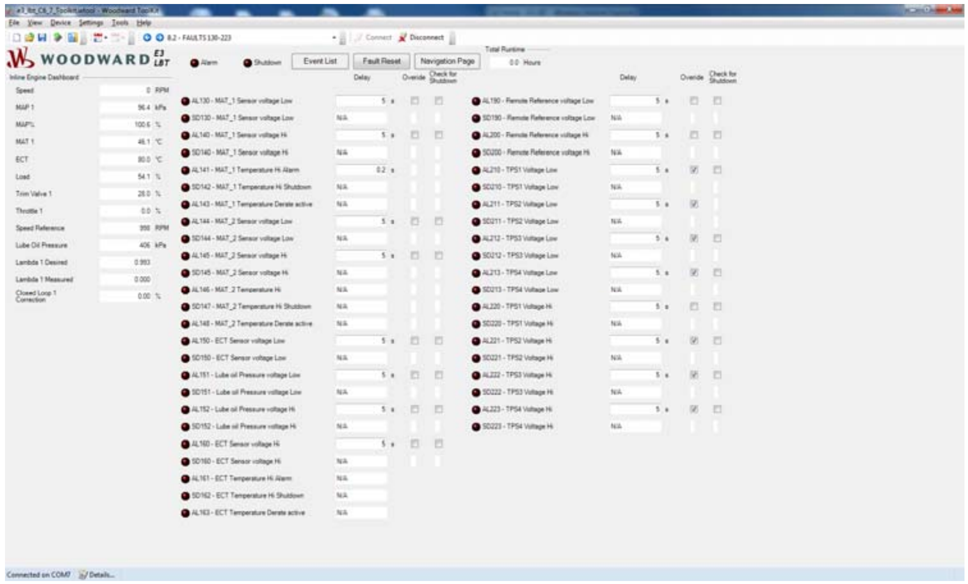
Figure 4-25 shows the HMI user settings for sensor alarm and shutdown configuration. The alarm delay for each sensor can be set by the user to prevent false alarms that might be caused by “glitches”. The alarms with a checkbox under the heading “Shutdown” can be configured by the user to cause a shutdown when the alarm is triggered, by placing a checkmark in the box. Leaving the box unchecked will result in an alarm only. During system commissioning and for troubleshooting in service, alarms for sensors that have a checkbox under the column heading “Override” can be disabled, by placing a checkmark in the box.

Optional engine protection features can be selected and configured using the HMI. Selection of each feature is done on the HMI screen 8.12 titled “8.12 – ALM/SD – Sensors”. Each of these features is described in detail below.

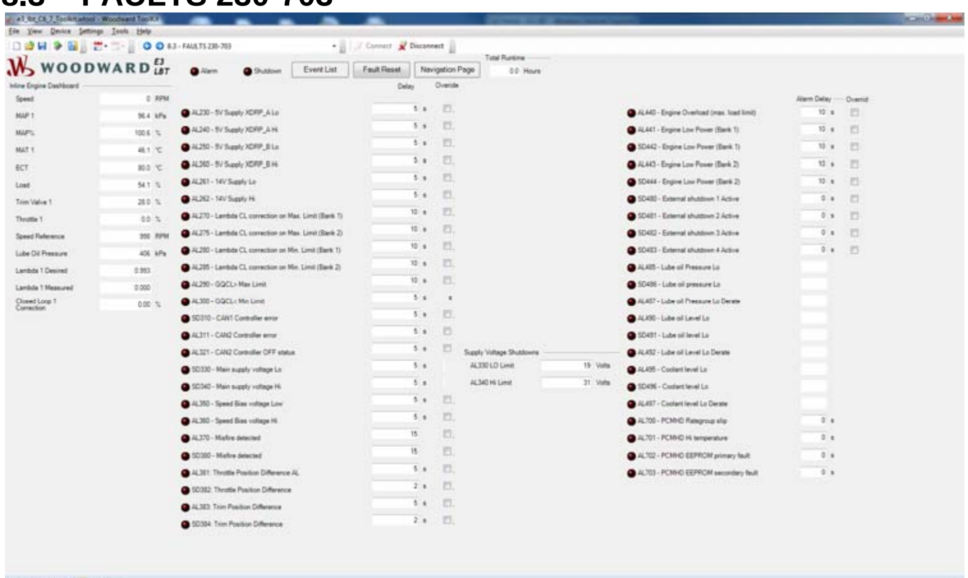
8.1 – FAULTS 01-124



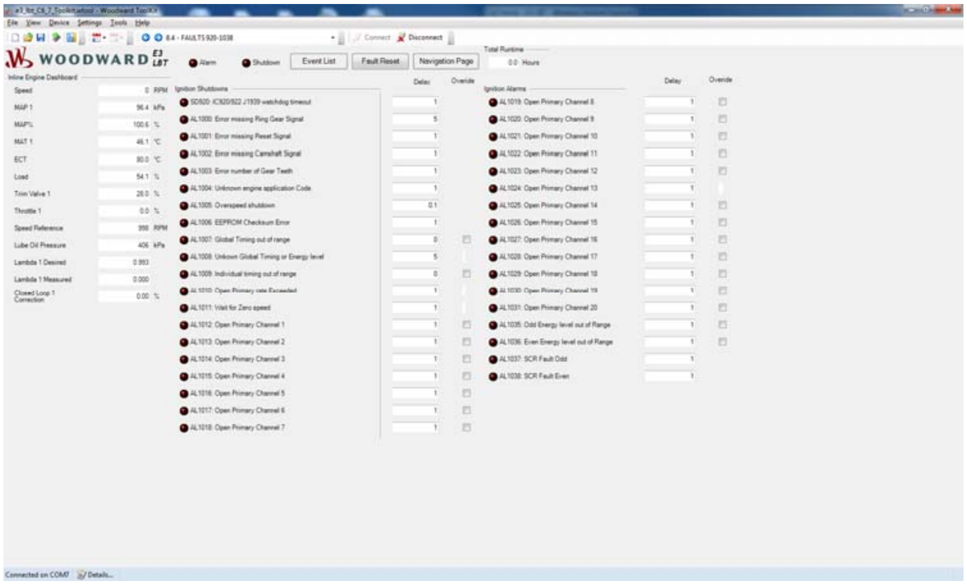
8.2 – FAULTS 130-223



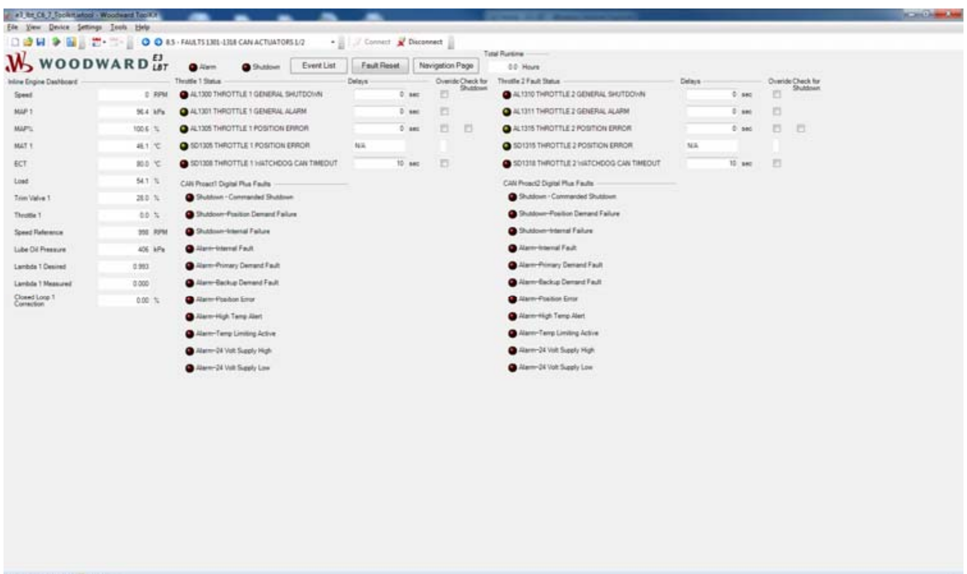
8.3 – FAULTS 230-703



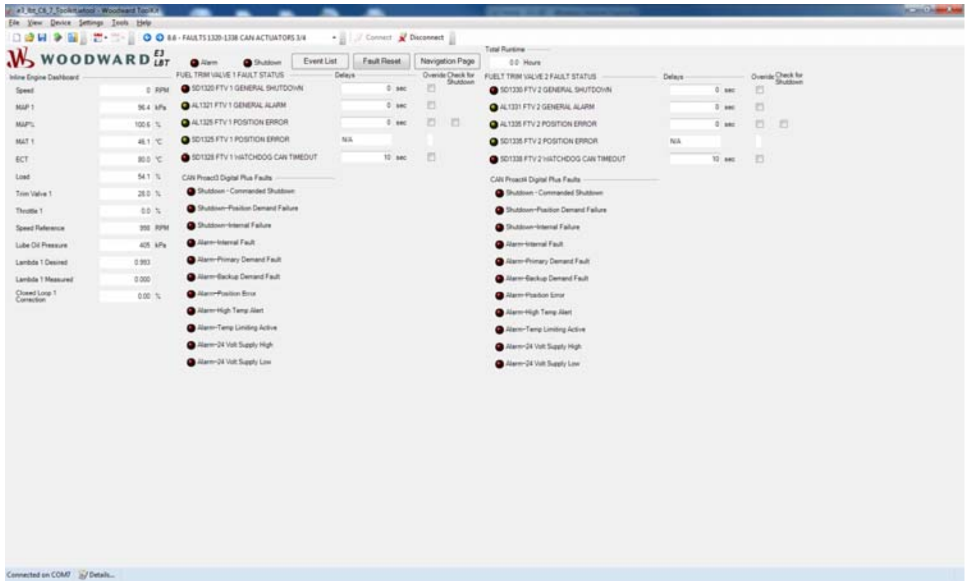
8.4 – FAULTS 920-1038



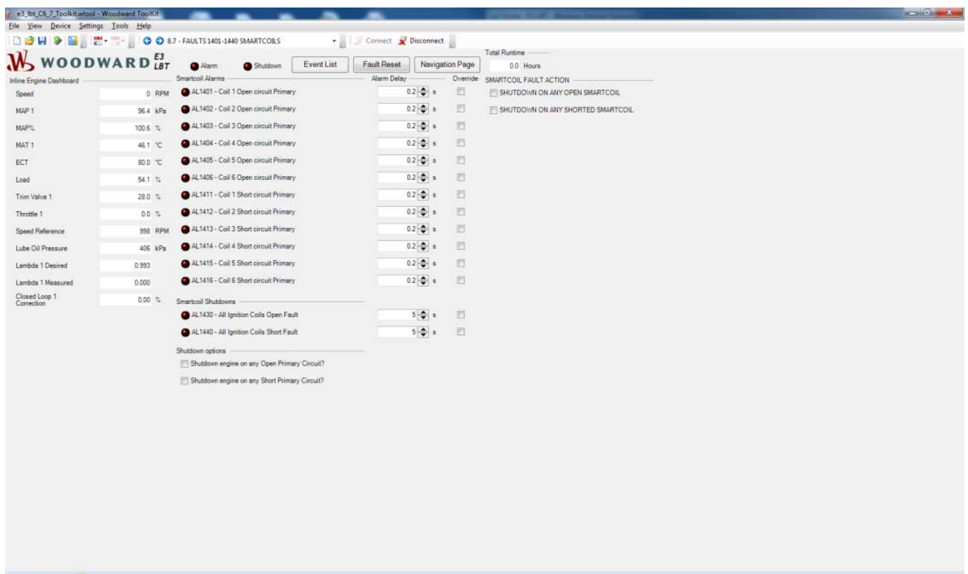
8.5 – FAULTS 1301-1318 CAN ACTUATORS 1/2



8.6 – FAULTS 1320-1338 CAN ACTUATORS 3/4



8.7 – FAULTS 1401-1440 SMARTCOILS



8.8 – FAULTS MAT/ECT DERATE

ECT Engine Protection

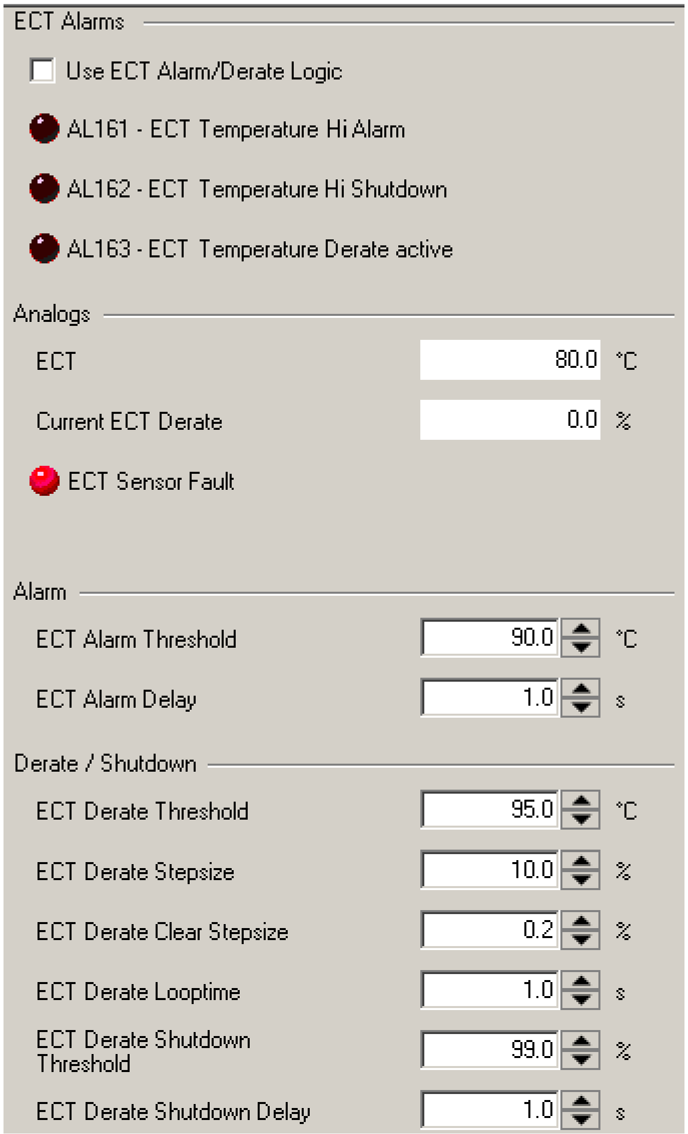


Figure 2-88. HMI Settings for ECT Engine Protection (HMI Screen 8.5)

The HMI settings for ECT engine protection are shown in Figure 2-88. This feature is only active if an ECT sensor is used and enabled in the system. The default settings are configured to shutdown the engine if sensed ECT exceeds the user input value for “ECT Derate Threshold”. If the user input value for “ECT Alarm Threshold” is lower than the “ECT Derate Threshold”, the “ECT Temperature Hi Alarm” will trigger if the sensed ECT exceeds this value, without triggering an engine shutdown. In this case, the alarm will only activate after the “ECT Alarm Delay” time has expired.

If the user wishes to utilize the Derate function in order to protect the engine without shutting down, the “ECT Derate Shutdown Threshold” can be set to a value less than 100%, and the “ECT Derate Loop time” and “ECT Derate Stepsize” can be set to values that result in the desired level of engine derate protection. When configured to provide engine derate protection, this function will incrementally derate engine speed (or load, depending on operating mode) by the “ECT Derate Stepsize”, every “ECT Derate Looptime” seconds that the sensed ECT exceeds the “ECT Derate Threshold”. If the resulting speed or load derate reaches the user defined “ECT Derate Shutdown Threshold”, the shutdown function will then trigger, after the “ECT Derate Shutdown Delay” has expired.

MAT Engine Protection

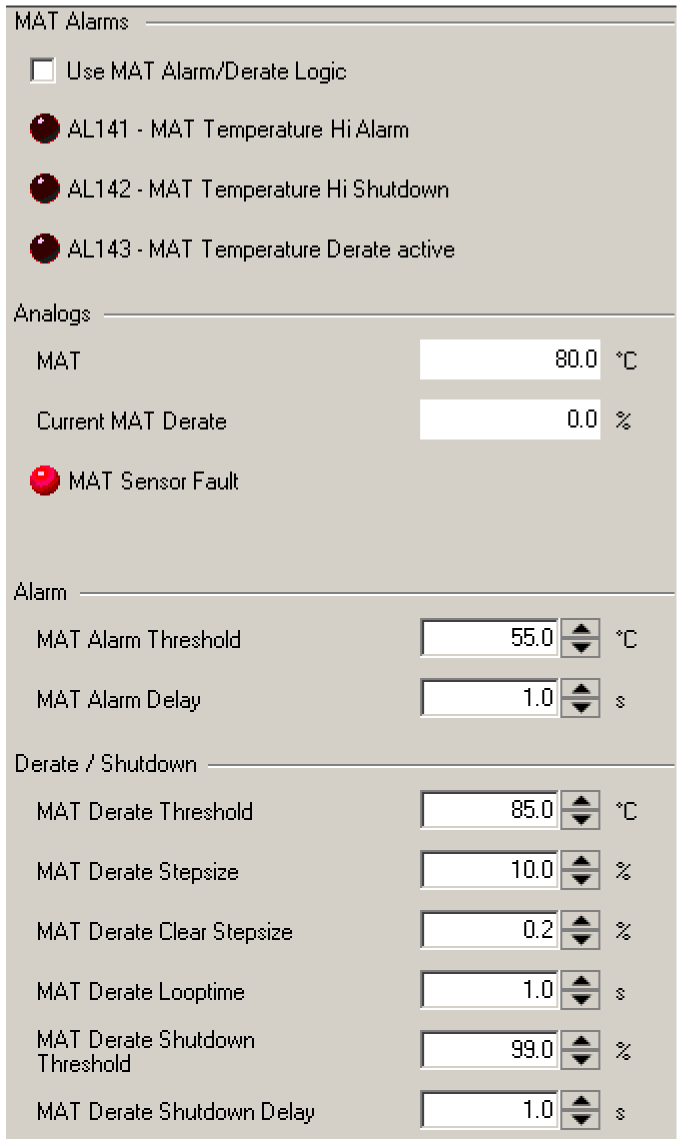
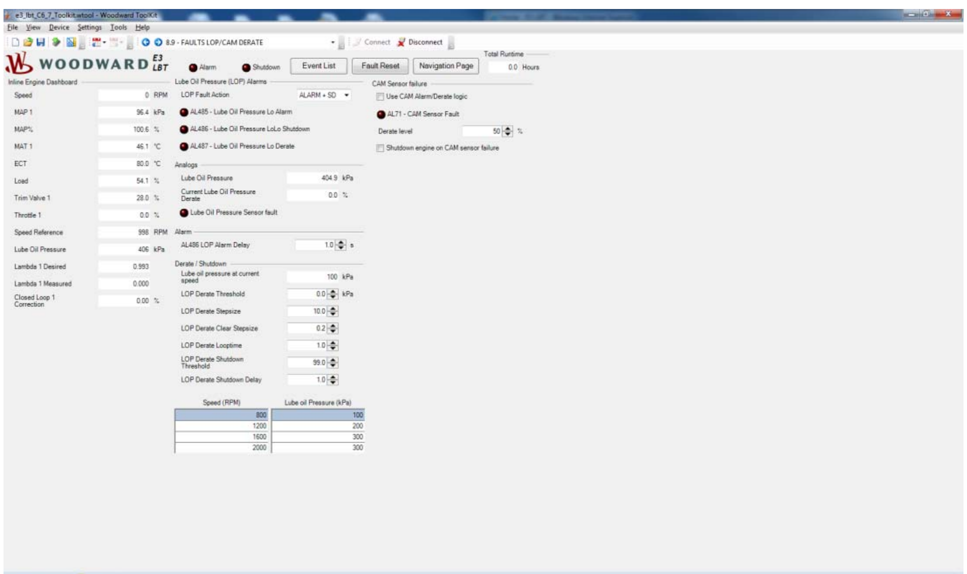


Figure 2-89. HMI Settings for MAT Engine Protection (HMI Screen 8.5)

The HMI settings for MAT engine protection are shown in Figure 2-89. The default settings are configured to shutdown the engine if sensed MAT exceeds the user input value for “MAT Derate Threshold”. If the user input value for “MAT Alarm Threshold” is lower than the “MAT Derate Threshold”, the “MAT Temperature Hi Alarm” will trigger if the sensed MAT exceeds this value, without triggering an engine shutdown. In this case, the alarm will only activate after the “MAT Alarm Delay” time has expired.

If the user wishes to utilize the derate function in order to protect the engine without shutting down, the “MAT Derate Shutdown Threshold” can be set to a value less than 100%, and the “MAT Derate Looptime” and “MAT Derate Stepsize” can be set to values that result in the desired level of engine derate protection. When configured to provide engine derate protection, this function will incrementally derate engine speed (or load, depending on operating mode) by the “MAT Derate Stepsize”, every “MAT Derate Looptime” seconds that the sensed MAT exceeds the “MAT Derate Threshold”. If the resulting speed or load derate reaches the user defined “MAT Derate Shutdown Threshold”, the shutdown function will then trigger, after the “MAT Derate Shutdown Delay” has expired.

8.8 – FAULTS LOP/CAM DERATE



Lube Oil Pressure Engine Protection

The HMI settings for lube oil pressure engine protection are shown in Figure 2-51. This feature is only active if a lube oil pressure sensor is used and enabled in the system, and the checkbox beside “Use LOP Alarm/Derate Logic” is checked. The default settings are configured to shutdown the engine if the difference between the sensed lube oil pressure and the user specified transfer function “Lube oil Pressure (kPa)” vs. “Speed (RPM)” exceeds the user specified protection margin “LOP Derate Threshold”. If the user wishes to utilize the derate function in order to protect the engine without shutting down, the “LOP Derate Shutdown Threshold” can be set to a value less than 100%, and the “LOP Derate Looptime” and “LOP Derate Stepsize” can be set to values that result in the desired level of engine derate protection.

In either case, the alarm/derate or shutdown activity will trigger only after the "LOP Alarm Delay" has elapsed.

When configured to provide engine derate protection, this function will incrementally derate engine speed (or load, depending on operating mode) by the "LOP Derate Stepsize", every "LOP Derate Looptime" seconds that the sensed Lube Oil Pressure exceeds the "LOP Derate Threshold". If the resulting speed or load derate reaches the user defined "LOP Derate Shutdown Threshold", the shutdown function will then trigger, after the "LOP Derate Shutdown Delay" has expired.

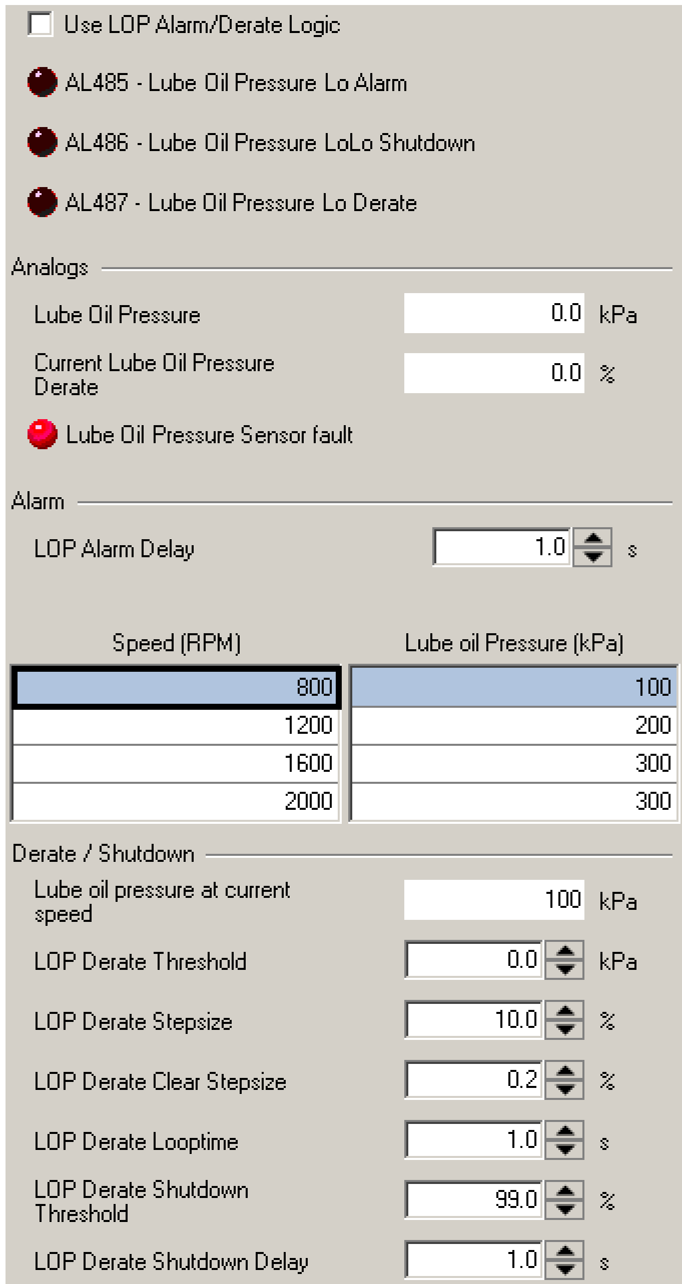
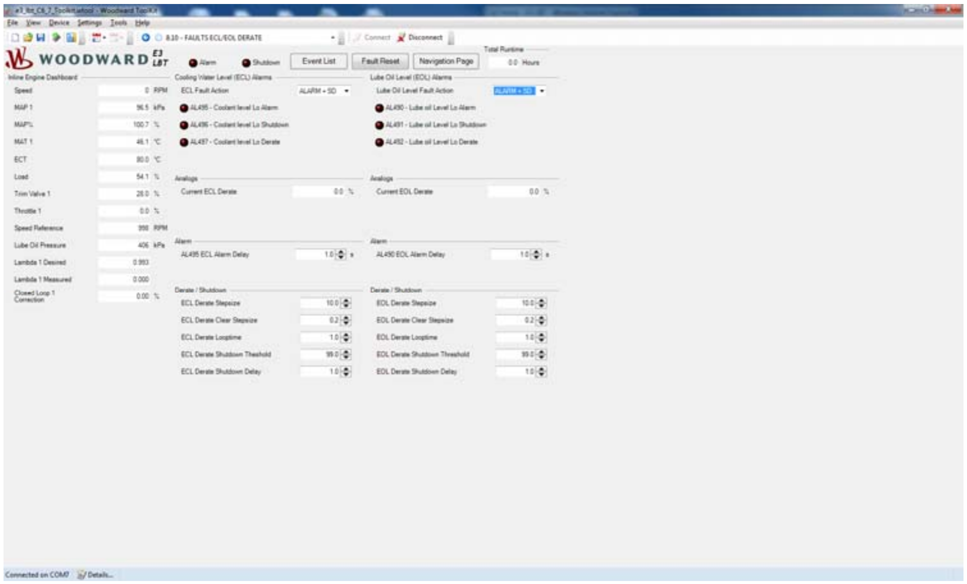


Figure 2-90. HMI Settings for Lube Oil Pressure Engine Protection (HMI Screen 8.6)

8.10 – FAULTS ECL/EOL DERATE



Lube Oil Level Engine Protection

The HMI settings for lube oil level engine protection are shown in Figure 2-91. This function is only active when if the box next to “Use EOL Derate/Alarm Logic” is checked”. The default settings are configured to shutdown the engine if no voltage is sensed on the PCM128-HD lube oil level input (see control wiring diagram in Chapter 6). Note that this function is active only when the engine is stopped. This is intended for engines whose oil level may be below the sensor during normal operation. If the lube oil level engine protection is desired when the engine is running as well, please contact Woodward.

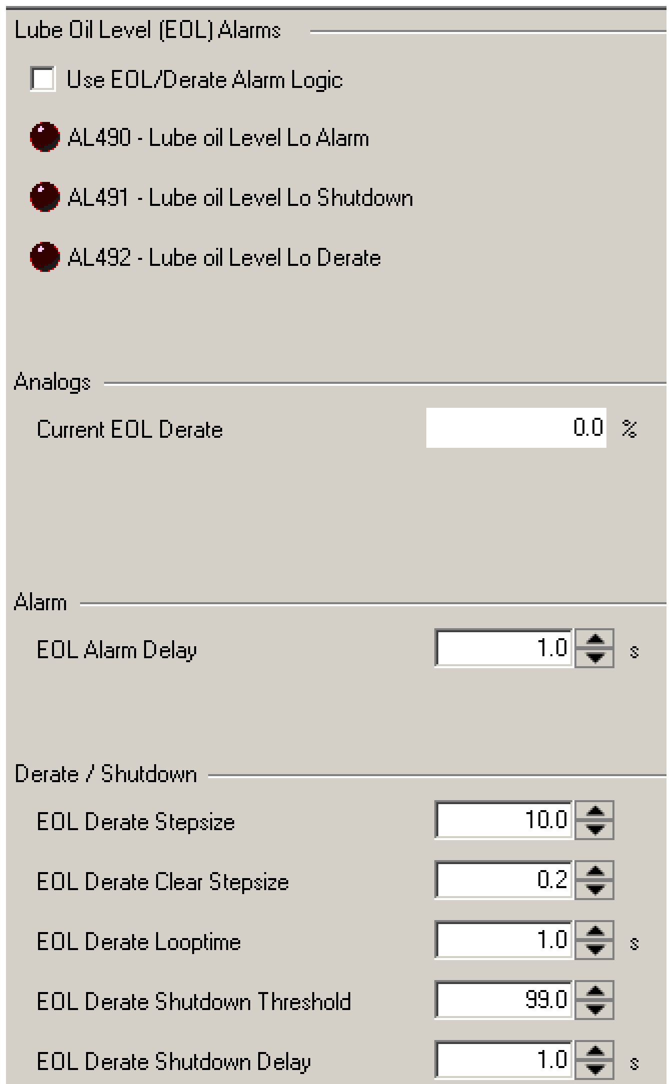


Figure 2-91. HMI Settings for Lube Oil Level Engine Protection (HMI Screen 8.7)

Engine Coolant Level Engine Protection

The HMI settings for engine coolant level engine protection are shown in Figure 2-92. This function is only active when if the box next to “Use ECL Derate/Alarm Logic” is checked”. The default settings are configured to shutdown the engine if no voltage is sensed on the PCM128-HD coolant water level input (see control wiring diagram in Chapter 6). If the user wishes to utilize the derate function in order to protect the engine without shutting down, the “ECL Derate Shutdown Threshold” can be set to a value less than 100%, and the “ECL Derate Looptime” and “ECL Derate Stepsize” can be set to values that result in the desired level of engine derate protection.

In either case, the alarm/derate or shutdown activity will trigger only after the “ECL Alarm Delay” has elapsed.

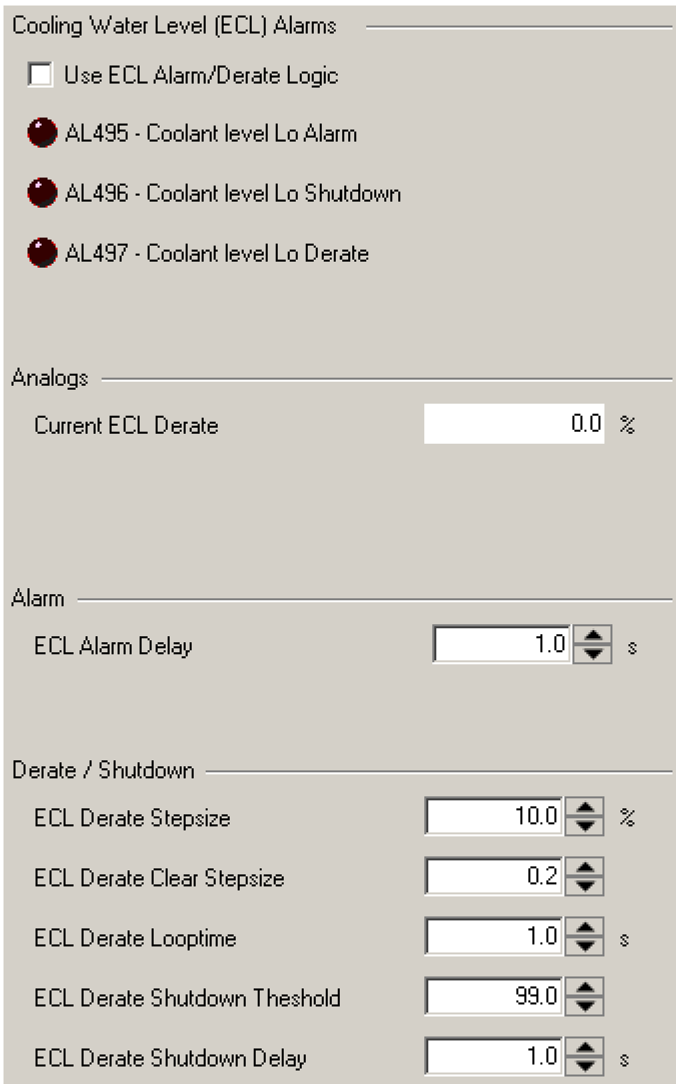


Figure 2-92. HMI Settings for Engine Coolant Level Engine Protection (HMI Screen 8.7)

When configured to provide engine derate protection, this function will incrementally derate engine speed (or load, depending on operating mode) by the “ECL Derate Stepsize”, every “ECL Derate Looptime” seconds that the sensed Coolant water level exceeds the “ECL Derate Threshold”. If the resulting speed or load derate reaches the user defined “ECL Derate Shutdown Threshold”, the shutdown function will then trigger, after the “ECL Derate Shutdown Delay” has expired.

CAM Sensor Fault Engine Protection

The aim of this function is to provide a configurable alarm/derate/shutdown for protection against misfire, backfire and knock when there is a cam sensor fault. The HMI settings for this function are shown in Figure 2-93. The function is enabled by checking the box beside “Use CAM Alarm/Derate logic” (note, this function is applicable only to Pattern 2).

The CAM sensor fault engine protection alarm/derate or shutdown functions are triggered by AL71 (CAM Sensor failure). For more information, see *AL71 (CAM Sensor failure)* in Chapter 5.

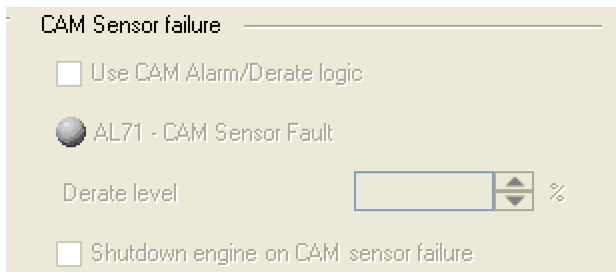


Figure 2-93. Cam Sensor Fault Engine Protection Settings (HMI Screen 8.6)

Shutdown Function

When the box beside “Shutdown engine on CAM sensor failure” is checked, the engine will shut down immediately upon activation of AL71 (CAM Sensor failure).

Derate Function

When the box beside “Shutdown engine on CAM sensor failure” is unchecked and the “Derate level” is set to less than 100%, the engine will be derated to the specified level upon activation of AL71 (CAM Sensor failure).

Alarm Only

When the box beside “Shutdown engine on CAM sensor failure” is unchecked and the “Derate level” is set to 100%, there will be an alarm only, with no derate or shutdown upon activation of AL71 (CAM Sensor failure).

Air/Fuel Ratio (AFR) Control

Three types of AFR control are possible. The simplest is open loop control. This uses a trim valve lookup table and temperature correction to control the fuel to the engine. There is no feedback such as an UEGO sensor. The HMI settings for open loop trim valve control are shown in Figure 4-18.

There are two methods of closed loop AFR control available. One is lambda closed loop control using UEGO sensor feedback and the other method is gas quality closed loop (GQCL), available when a suitable kW feedback signal is provided to the E3 controller.

Lambda Closed Loop

The lambda closed loop control uses a lambda (UEGO) sensor to determine the actual air/fuel ratio and it compares this to the open loop lambda reference value.

The difference between the lambda reference and the measured lambda is the open loop error. An integrator acts on the trim valve position to move the error closer to zero. In this way lambda is always controlled at or near the required set point. This logic is depicted in Figure 2-94.

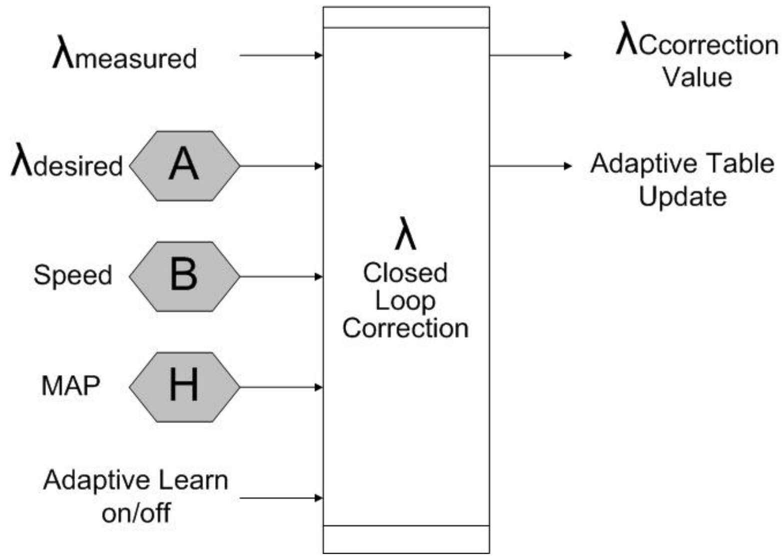


Figure 2-94. Lambda Closed Loop Correction

Gas Quality Closed Loop

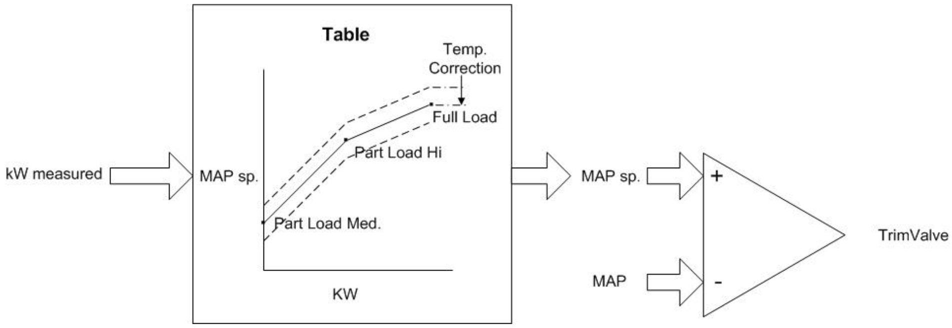


Figure 2-95. Gas Quality Closed Loop Control

Gas Quality Closed Loop (GQCL) uses the measured generator power (kWe), MAP & MAT signals as to infer changes in gas quality. The MAP set point is interpolated from a reference line which is defined by three pole points, Part load Med., Part Load Hi and Full Load. A manifold air temperature correction is applied to the reference line.

GQCL air/fuel ratio control acts in the following manner to maintain manifold pressure in accordance with the set point that is derived from the reference line. When the gas quality increases (i.e. higher energy density), at a constant trim valve set point and thus gas flow the load generated by the engine increases. Hence the actual load increases above that expected for the MAP set point. Due to speed/load control being performed by the E3 system, the throttle will close sufficiently to reduce the speed/load back to the set point. This will effectively also lower the MAP. The difference in MAP set point and MAP measured will generates a correction which results in reduction of the trim valve opening. This will result in the mixture becoming leaner, and the speed/load control will compensate by increasing the throttle opening to maintain the set point, resulting in an increase in MAP. A stable situation will be reached where the MAP measured equals the MAP set point while the MAP, Lambda and mixture flow are essentially the same as before the change. Only the gas flow demand has decreased because of a different trim valve position. When gas quality decreases, the same process works in the opposite direction.

Speed/Load Control

The Speed and Load Control functions use PID logic. In pump/compressor application mode or when the engine is running in generator application mode without load (generator breaker open) or with load but in island mode (generator breaker closed, but grid breaker open) the control uses a speed reference and the actual engine speed as inputs for the PID. When in grid mode (both the generator breaker and the grid breaker are closed and “kW Dynamics” is enabled in the HMI), a load set point and the actual measured mechanical load are the inputs for the PID.

PID Control

The PID controller compares the actual value with the set point. When the actual value is higher then the set point the PID output will decrease, when the actual value is lower then the set point the PID output will increase. There are 3 different control settings that determine the dynamic behavior of the PID:

- Proportional Gain
- I-gain
- Derivative

The above-mentioned PID settings can be attributed to different time domains. The proportional action reacts on the present situation, the Integral action reacts on the past and the derivative action predicts what will happen and reacts on that.

The output of a PID controller will change in response to a change in measurement or set-point. Tuned PID combinations of proportional, integral, and derivative will provide the best type of process control required. Figure 2-96 shows the process response to a perturbation with different combinations of P, I, and D control.

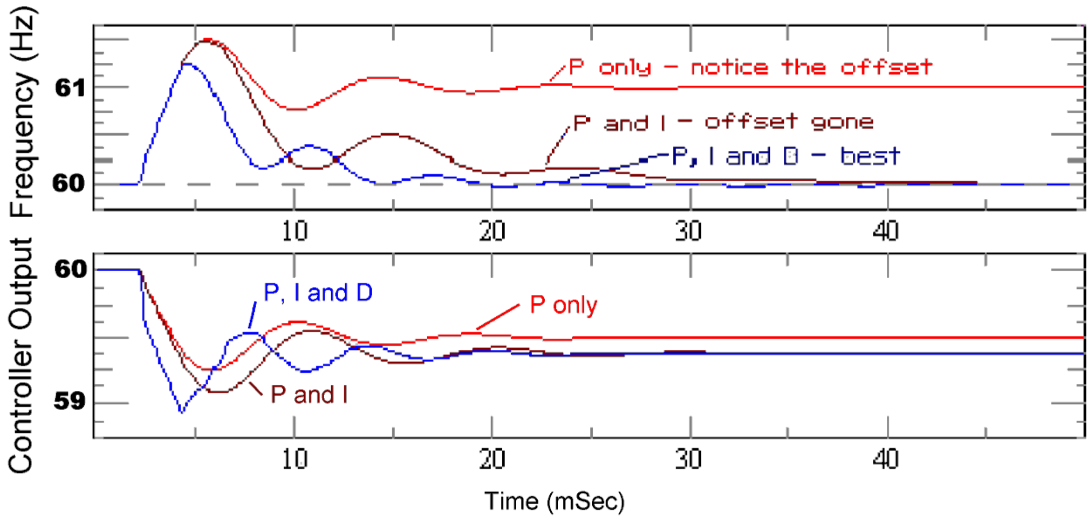


Figure 2-96. PID Response

Proportional Gain
The proportional response of the PID is proportional to the difference between the actual process value and the setpoint. This difference can be due to a change in the set point or a change in the actual process value. The PID responds on a difference between the two inputs (input error). The higher the Proportional Gain, the higher the output change on the same input error.

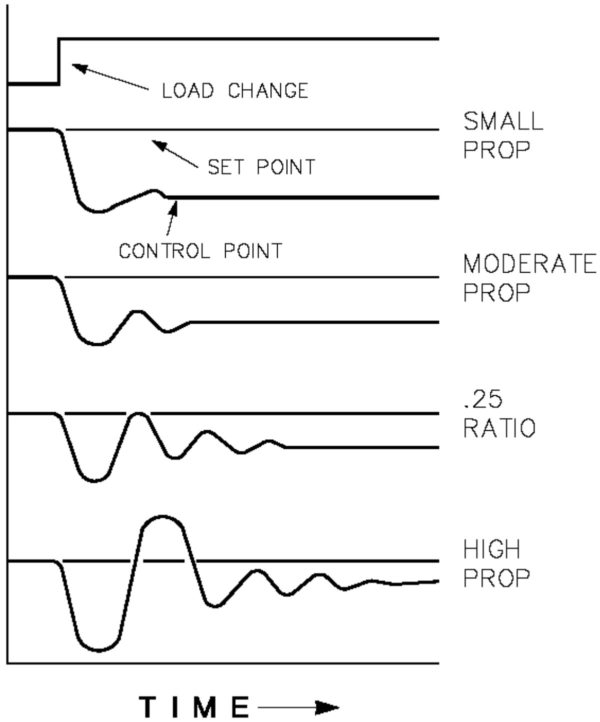


Figure 2-97. Effect of Proportional Gain Settings on Control

In Figure 2-98 the process response to a load change is shown. The process is controlled by a proportional correction only. The process response of a control with a low P-gain is stable, but has a slow correction and a large offset. A high P-gain will result in a faster response that gives a smaller offset but less stability. An optimum needs to be found in a fast enough response and a minimum of instability or ringing. The offset needs to be removed with the Integral action (reset rate).

In the case of a speed control on a gas engine, the proportional response will result in a new position of the throttle. In the Figure 2-98, the relationship between an increasing setting of the Proportional Gain and the PID response is shown. The response of the control on a Proportional Gain setting is:

Output = Prop. Gain x (Set Point – Process Value)

The graphs are shown with a constant I-gain and Derivative action.

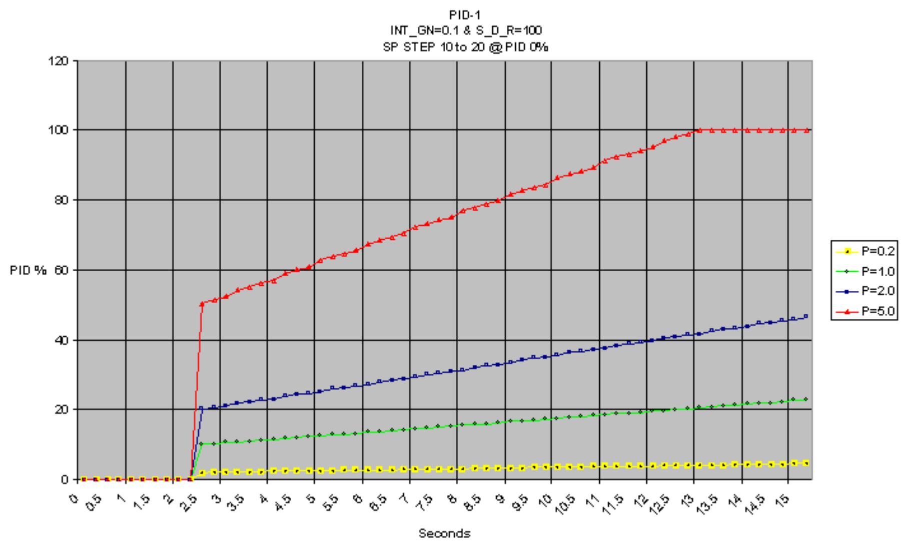


Figure 2-98. Proportional Gain with Fixed Integral and Derivative

Integral Action (I-gain)

I-gain—The I-gain is the integral term in the PID controller. With integral action, the control's output is proportional to the amount of time the speed error is present. It controls the time rate at which the speed error returns to zero after a speed or load disturbance. Figure 2-99 shows the process response to different integral settings.

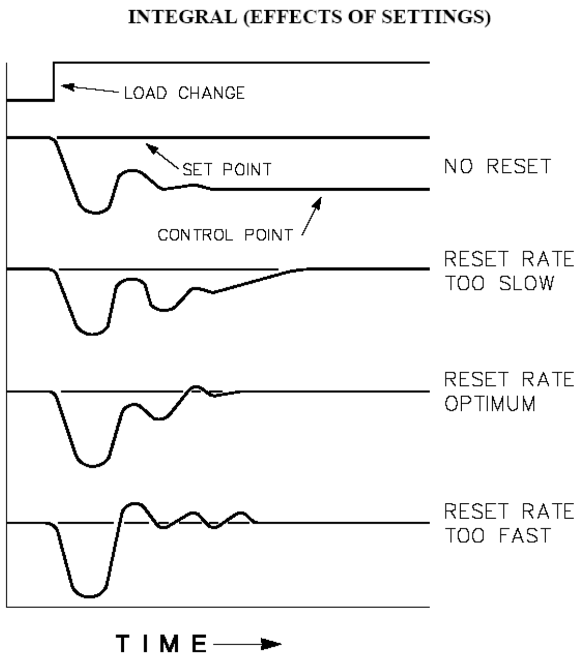


Figure 2-99. Effect of Integral Action on Control

The response of the process on a load change without integral action is shown in the second graph. There will be an offset that persists. When integral action is performed in the PID, the offset will be removed from the process. The greater the integral action, or faster the I-gain rate, the faster the control will remove the offset between the process value and the set point. When the integration is too fast, there will be overcompensation and an oscillation will occur.

$$\text{Output} = \text{P-gain} \times \left[\frac{\text{I-gain}}{s} + 1 \right] \times (\text{setpoint} - \text{process value})$$

$$\text{I-gain} = \frac{1}{Ti}$$

$$\text{Output} = \text{P-gain} \times \left[\frac{1}{Ti \cdot s} + 1 \right] \times (\text{setpoint} - \text{process value})$$

The integral output is a function of the magnitude and duration of the input error. It also depends on the adjustment of the integral action in the PID control. Figure 2-100 illustrates the effect of different integral gain settings in the PID control. The higher the setting of the integral gain, the faster it will change the output signal to integrate the input error to zero.

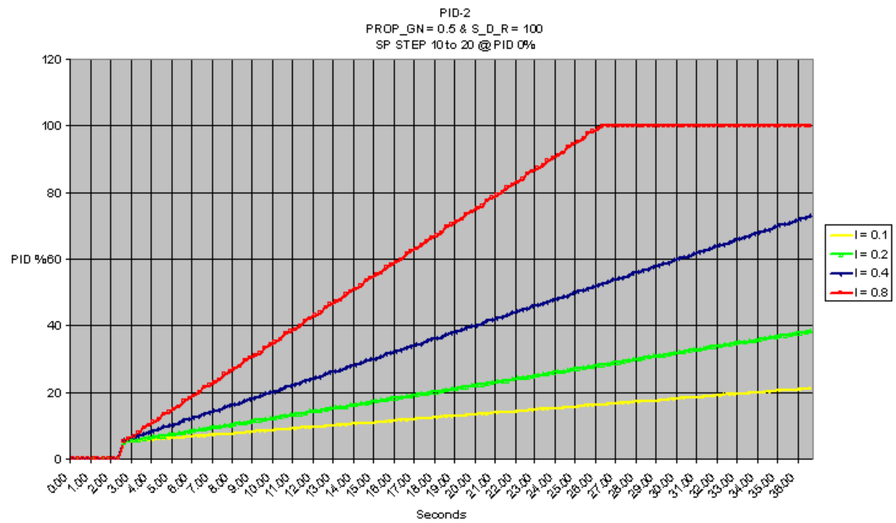


Figure 2-100. Integral Action when Using a Fixed P-gain and no Derivative

The graph can be explained using the calculation above. For example a I-gain of 0.4 (second graph from the top), this means a Ti = 2.5 seconds. A P-gain of 0.5 is used.

$$Ti = \frac{1}{\text{I-gain}} = \frac{1}{0.4} = 2.5$$

$$\text{Output} = 0.5 \text{ x } \left[\frac{1}{2.5s} + 1 \right] \text{ x } (10)$$

$$\text{Output} = \frac{2}{s} + 5$$

The output at i.e. 20 s is 20-2.5 s = 17.5 s since the step on the input,
Output = (2 x 17.5) + 5 = 40

Derivative Action (SDR or Speed Derivative Ratio)
SDR (Speed Derivative Ratio)–is the derivative term used in the PID controller. With derivative action, the control's output is proportional to the rate of change of the measurement or error.

The control's output is calculated by the rate of change of the measurement with time. SDR (Speed Derivative Ratio) is used to avoid overshoot.

Input Dominant is much jumpier and more responsive. Typically used in Line drives where the quickest response possible is needed. It can be a little unstable - almost jittery.

- Input Dominant is 0.01 < D < 1.00
- Feedback Dominant is 1.00< D < 100

In the E3 control default settings are Feedback dominant SDR (Speed Derivative Ratio) values.

The derivative acts on the rate of change of the control error. Consequently, it is a fast mode which ultimately disappears in the presence of constant errors. It is sometimes referred to as a predictive mode, because of its dependence on the error trend. The main limitation of the derivative mode, viewed in isolation, is its tendency to yield large control signals in response to high-frequency control errors, such as errors induced by set-point changes or measurement noise. Figure 2-101 shows the process response to different derivative calibrations.

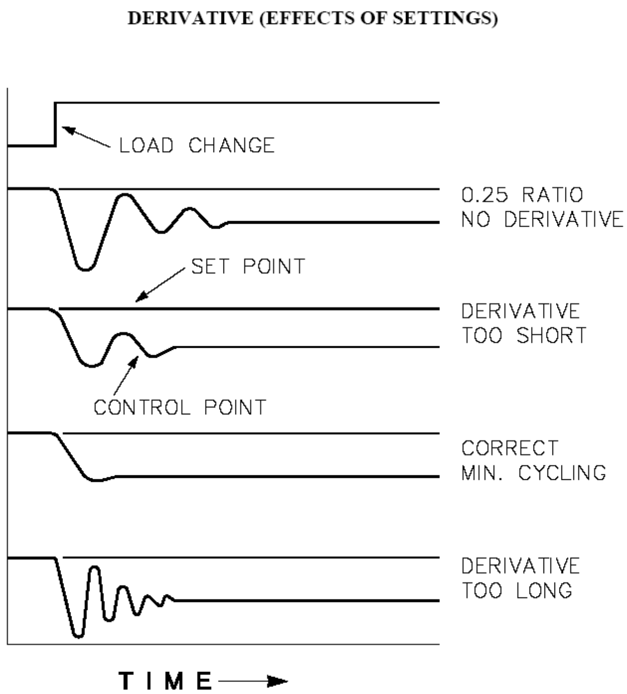


Figure 2-101. Effect of Derivative Action on Control

The net result of derivative action is to oppose any process change and combined with Proportional action to reduce stabilization time in returning the process to the set point after an upset. The derivative will not remove offset.

The Woodward implementation of the derivative action is split into two working domains, Input Dominant and Feedback Dominant.

- Input Dominant uses the output of the summing point to calculate the D component of the PID.
- Feedback Dominant uses the Present Feedback signal to calculate the next D component of the PID.

The allowed values for the SDR (Speed Derivative Ratio) range from 0 – 100. The common derivative is feedback dominant, it is automatically selected with an SDR (Speed Derivative Ratio) from 1 to 100. The less common SDR (Speed Derivative Ratio) is input dominant and is selected with SDR (Speed Derivative Ratio) values between 0 and 1.

Feedback dominant applies the derivative action to the integrator feedback term of the PID equation and is more stable than input dominant derivative. This will not take corrective action as early and will be less noise sensitive.

Input dominant derivative applies the SDR (Speed Derivative Ratio) term before the integrator term of the PID equation. When the SDR (Speed Derivative Ratio) is less than 1, the derivative is input dominant and reacts very quickly to process upsets. It is very sensitive, so it should only be used in applications free of high frequency noise.

The reciprocal setting of the SDR (Speed Derivative Ratio) in one domain will appear identical in the other domain. As an example, the setting of an SDR (Speed Derivative Ratio) of 5.0 will appear the same as and SDR (Speed Derivative Ratio) of 0.2. The difference in response is due to the dominance features.

The equation below is the feedback dominant transfer function of the Woodward PID implementation.

$$\text{Output} = \text{P-gain} \times \left[\frac{\text{I-gain}}{s} + 1 \right] \times \left[\frac{s}{\text{SDR} \times \text{I-gain}} + 1 \right] \times (\text{Setpoint} - \text{Process value})$$

The input dominant transfer function of the Woodward PID implementation is given in the following equation.

$$\text{Output} = \text{P-gain} \times \left[\frac{\text{I-gain}}{s} + 1 \right] \times \left[\frac{\text{SDR} \times s}{\text{I-gain}} + 1 \right] \times (\text{Setpoint} - \text{Process value})$$

In Figure 2-102 the PID response on a step change is illustrated while using a fixed P-gain and Integral action (in the feedback dominant domain). It shows that an SDR (Speed Derivative Ratio) setting of 1 gives the highest reaction on an input change. A setting of 50 in the SDR (Speed Derivative Ratio) gives almost no effect on the output on a change in input.

Dynamic Settings Selection

The Speed and Load dynamics depend on operator selections and engine running modes. The following selection is be made by the user:

- Fixed dynamics or variable dynamics.
- Variable dynamics have two options:
  - Dynamics not depending on speed or load
  - Dynamics depending on speed or load

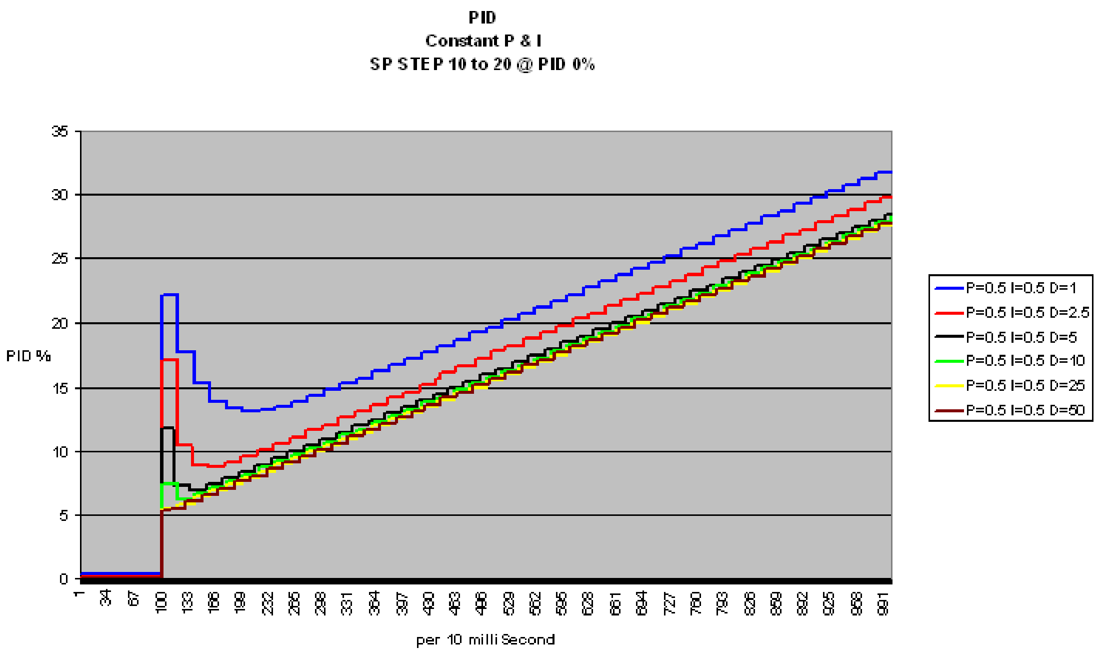


Figure 2-102. Derivative with Fixed Proportional Gain and Integral Action

Variable Dynamics

When the P, I, or D fixed gain is not selected, the corresponding variable gain curve will be active. These variable dynamics depend on the engine mode (generator breaker status and grid breaker status).

There are 3 different variable dynamics selections possible. Figure 2-103 shows the logic used for selecting dynamics in different operating modes. The 3 modes are:

- Dynamics 1 – Speed control mode (both the generator breaker and the grid breaker are open)
- Dynamics 2 – Island mode (the generator breaker is closed but the grid breaker is open) – Generator application only
- Dynamics 3 – Load Control (Grid mode) mode (both the generator breaker and the grid breaker are closed; the engine is parallel to the grid) – Generator application only

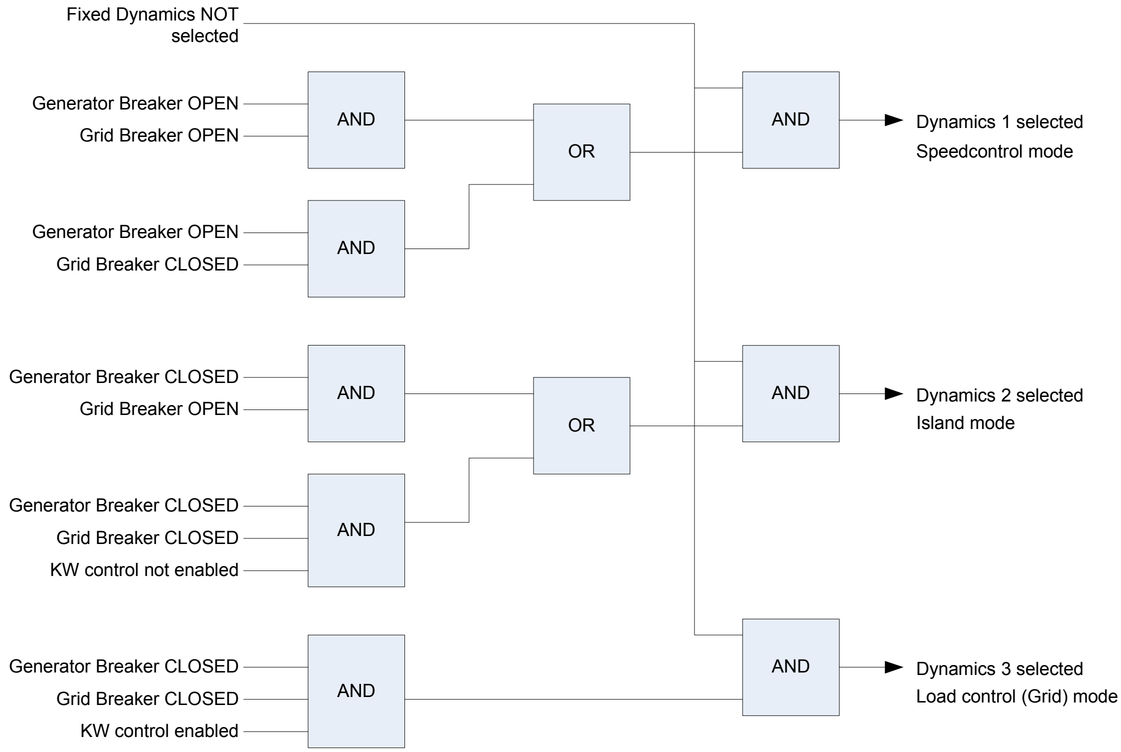


Figure 2-103. Dynamics Selection Logic

The proportional gain depends on a curve block and a ratio factor in dynamics 1 and 2. The MAP% curve block has MAP% as an input and the output is a gain factor. The ratio factor is active when the absolute value of the speed error (actual speed – speed set point) exceeds a tunable value. The output of the curve block and the ratio factor are multiplied and the result is the final gain value. In this way the curve can be used for a partial influence on the final result.

In dynamics 3 mode (on grid) the gain is determined through 1 curve block that receives its input from the generator load.

Chapter 3.
Hardware Installation

Introduction

This chapter includes instructions for E3 Lean Burn Trim hardware installation. The system includes the following required or optional components and inputs/outputs:

- E3 control module (PCM128-HD)
- Engine speed sensor
- Engine phase (camshaft position) sensor
- Manifold pressure sensor
- Manifold temperature sensor
- Engine coolant temperature sensor
- Engine protection sensors: oil pressure, oil level, coolant level
- Analog Inputs (0–5 V)
  - Generator Power input
  - Remote Speed/Load reference
  - Speed reference bias, synchronizer or load control
- Bosch LSU 4.2 UEGO sensor (commissioning or permanent)
- Discrete Inputs and Outputs
- IC-920/922 Ignition system
- Woodward Smart Coils
- easYgen-3100/3200 power management controller

Figure 3-1. System Overview

Control Module

⚠WARNING	**EXPLOSION HAZARD—Do not connect or disconnect while circuit is live unless area is known to be non-hazardous.** **Substitution of components may impair suitability for Class I, Division or Zone applications.**

⚠WARNING	**The control will only meet ingress protection specifications with all mating connectors properly installed. In addition, all unused connections in the mating connectors must be plugged to ensure proper sealing of the connectors. Refer to Table 3-1 for the proper Connector Plug part numbers. Failure to adhere to these guidelines may result in product failure or decreased product life.**

⚠WARNING	**Due to the hazardous location listings associated with this product, proper wire type and wiring practices are critical to operation.**

NOTICE	**Do not connect any cable grounds to “instrument ground”, “control ground”, or any non-earth ground system. Make all required electrical connections based on the wiring diagram (Chapter 6).**

Control Module Power Requirements

The PCM128-HD requires a voltage source of 12 to 32 Vdc. (12 or 24 Vdc nominal) The power dissipation within the control is typically less than 15 W.

IMPORTANT	**Total power consumption for both the control and the driven load is dependent upon the application. A typical application may require 0.5 to 0.8 kW to drive the loads under all operating conditions. The power source must be sized appropriately for the application.**

NOTICE	**To prevent damage to the control, do not exceed the input voltage range.**

IMPORTANT	**If a battery is used for operating power, an alternator or other battery-charging device is necessary to maintain a stable supply voltage.**

NOTICE	**To prevent damage to the control, make sure that the alternator or other battery-charging device is turned off or disconnected before disconnecting the battery from the control.**

Location of Control Module

Consider these requirements when selecting the mounting location:

- Adequate ventilation for cooling. Select a location on the engine that will provide an operating temperature range of –40 to +85 °C (–40 to +185 °F). A position low on the engine is more likely to be in this temperature range.
- Space for servicing and repair.
- Protection from direct exposure to water or to a condensation-prone environment.
- Protection from high-voltage or high-current devices, or devices which produce electromagnetic interference in excess of levels defined in EN61000-6-2 (Immunity).
- Avoidance of high vibration. Vibration or shock dampeners should be used when mounting the control.
- The control should be electrically grounded to the engine. If the control is mounted inside an enclosure, it should be a metallic enclosure and attached to the engine such that the engine and enclosure have the same ground potential.
- Wiring to and from the control should be routed within two inches of engine-ground-potential structural components to minimize subjecting the control to electromagnetic interference.
- Mounting dimensions and instructions are shown in Figure 3-2.

Mounting of Control Module

Mount the control module using the included vibration dampeners.

Bolt dimensions and torque to 8 N·m. Engine ground – 1” (25 mm) wide copper braid 18” (46 cm) in length max. Ensure that the mounting location does not subject the control module to environmental factors in excess of the limits specified in the PCM128-HD hardware manual (document 26309).

Electrical Connections

Figure 3-3 shows the E3 connector location and terminology. Table 3-1 provides information on the mating connectors. Table 3-2 is the list of tools to be used for the pinning of the ECU (PCM128-HD).

Table 3-1. Mating Connectors

Connector	**Woodward Part Number**	**Manufacturer’s Part Number**
J1-C and J2-A, 24-pin Connector	1635-1175	Tyco 4-1437287-5
J1-B and J2-B, 24-pin Connector	1635-1176	Tyco 4-1437287-6
J1-A, 32-pin Connector	1635-1177	Tyco 4-1437287-7
Terminal 18-20 AWG (0.91-1.16 mm)	1602-1028	Tyco 0-1437284-9
Terminal 14-16 AWG (1.46-1.84 mm)	1602-1029	Tyco 1-1437284-0
Plug (Seals unused pin locations)	1602-1030	Tyco 4-1437292-3
24 pin connector cover	1635-7001	Tyco 4-1437287-8
32 pin connector cover	1635-7002	Tyco 4-1437287-9

Table 3-2. Connector Tools

Tool	**Woodward Part Number**	**Manufacturer’s Part Number**
Crimper	8996-2041	Tyco 1456088-1
Extractor (steel)	8996-2052	Tyco 1437303-9

A connector kit is available with all mating connectors and pins: PN 8928-1096.

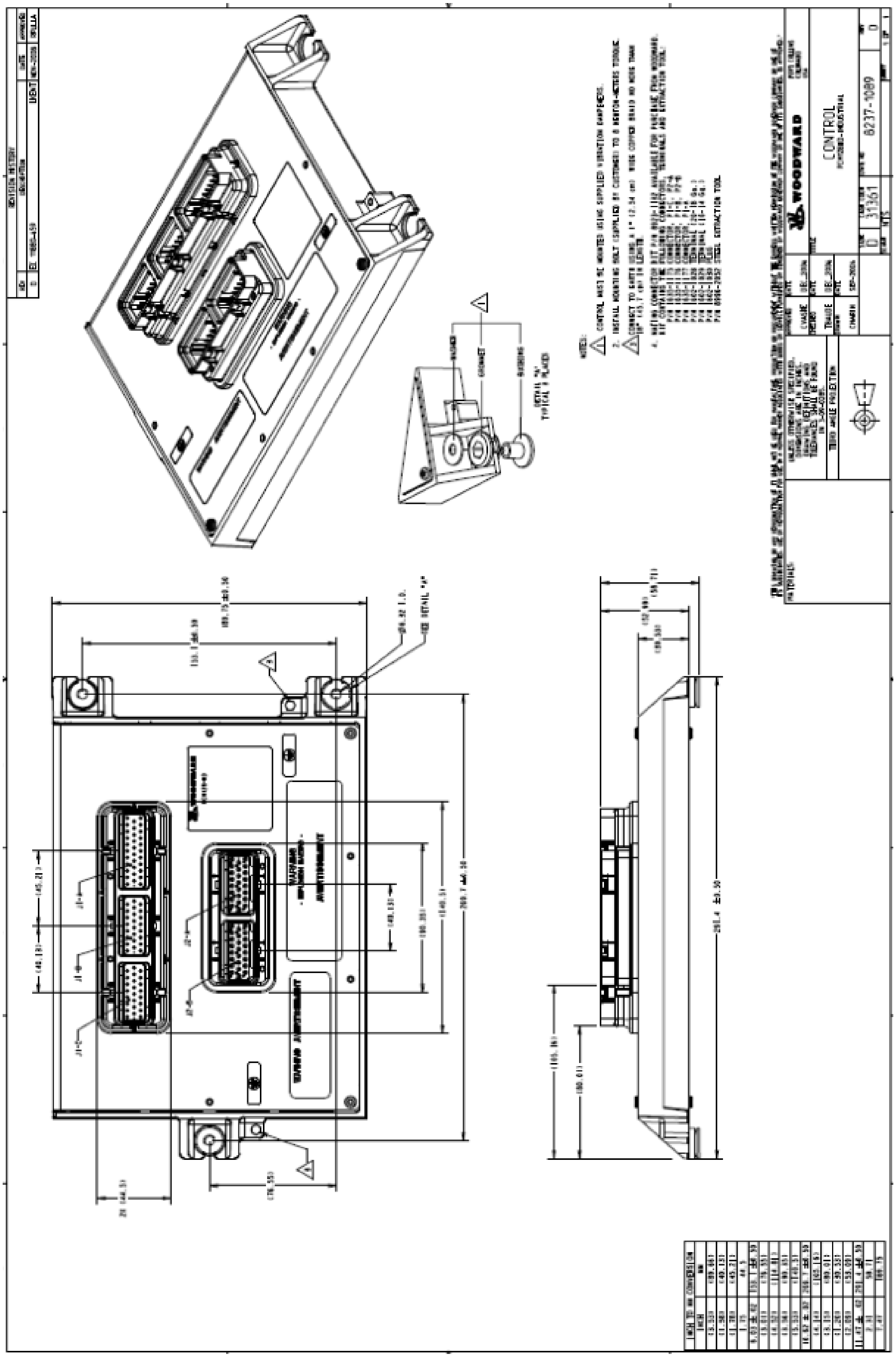


Figure 3-2. ECU (PCM128-HD) Hardware (PN 8237-1089)

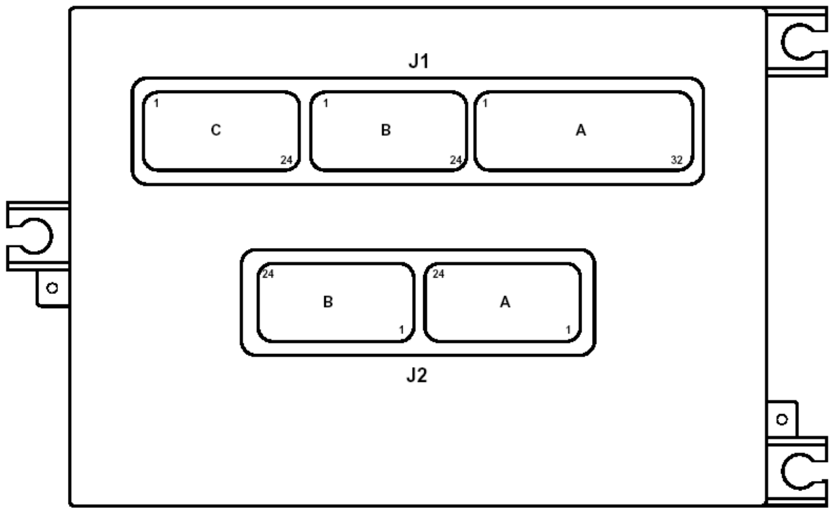


Figure 3-3. E3 Connector Terminology

Wiring Guidelines

IMPORTANT

DO NOT run signal wires next to wires carrying large currents (such as power source wiring).
- **All field wiring should be limited to < 30 meters in length.**
- **The power lines to the control should be limited to < 10 meters in length from the power supply.**

See Woodward application note 50532, *Interference Control in Electronic Governing Systems*, for more information.

Where shielded cable is used (such as cam or crank speed signals, UEGO sensor inputs, or communications signals), cut the cable to the desired length and prepare the cable as instructed below.

- Strip outer insulation from BOTH ENDS, exposing the braided or spiral wrapped shield. DO NOT CUT THE SHIELD.
- Using a sharp, pointed tool carefully spread the strands of the shield.
- Pull inner conductor(s) out of the shield. If the shield is the braided type, twist it to prevent fraying.
- Remove 6 mm (1/4 inch) of insulation from the inner conductors.
- Ground the shield at the source end and cut off the exposed shield at the receiving end.
- Installations with severe electromagnetic interference (EMI) may require additional shielding precautions. Contact Woodward for more information.

Transducer Ground
Most sensor inputs are single-ended. The low side of these sensors should be connected to transducer ground, which is PCM128-HD terminal J1-A24 (TRANSDUCER GROUND).

Shielded Wiring
Connect all shielded wires to ground on J1-B24 (SHIELDING GROUND) (not to J1-A24 (TRANSDUCER GROUND))

Power Inputs

Power supply output must be low impedance (for example, directly from a battery). DO NOT power the control from high-voltage sources with resistors and zener diodes in series with the control power input.

NOTICE

To prevent damage to the control, do not power a low-voltage control from high-voltage sources, do not exceed 32 V on the power inputs for more than 1 minute, and do not power any control from high-voltage sources with resistors and zener diodes in series with the power input.

NOTICE

The PCM128-HD Stationary Industrial control DOES NOT have the loss-of-battery detection capability. Removal of power from the main power input (J1-B8) prior to removing power from the keyswitch input (J1-B2) can result in loss and/or corruption of tunable and adaptive learn values, which may cause unpredictable behavior during subsequent engine operation.

Power Ground

Connect the power leads directly from the power source to the control. DO NOT POWER OTHER DEVICES WITH LEADS COMMON TO THE CONTROL. Avoid long wire lengths. Connect the battery positive (power source positive) to the J1-B2, J1-B8, J2-A18, and J2-A19 inputs and battery negative (power source common) to J2-A15, J2-A16, J2-A24, and J2-B9. If the power source is a battery, be sure the system includes an alternator or other battery-charging device. Power supply wiring is shown schematically in Figure 3-4.

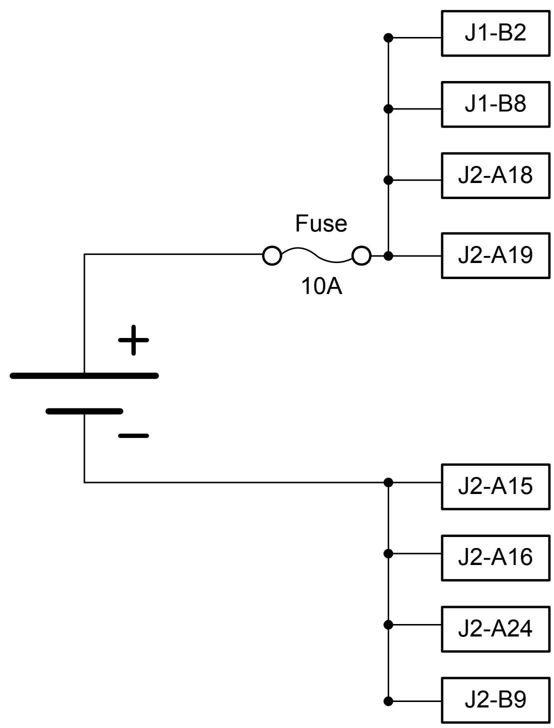


Figure 3-4. Power Supply Wiring

NOTICE

Proper fusing of the control is highly recommended to prevent damage to the control in case of shorts that may occur in the field wiring. Fuses should be wired in series with all the power inputs to the control.

Key Switch Input

The key switch (KEY_SW) discrete input provides a power-on wake-up command signal to the PCM128-HD control's internal power supply. Once activated the control's internal power supply will remain active until commanded to shutdown by the application program. A normally open switch is connected between battery positive and the KEY_SW input, thus connecting battery voltage to the control when the switch is closed; see Figure 3-5.

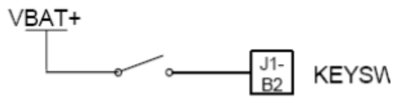


Figure 3-5. Key Switch Wiring Diagram

The voltage at this terminal is reported to the application. The voltage threshold level for the key switch is 10 V. Note that is a setting in E3 software.

If a switch is not used for the key switch input, this input should be powered whenever the system is powered.

Serial Communications Port (RS-485)

RS-485 is also an ANSI standard definition of electrical connections for communications between devices. Because it uses balanced drivers, it can communicate over long distances (1200 m/4000 ft) at high baud rates (115 K).

Interface Cables
When choosing a cable for RS-485, it is necessary to examine the required distance of the cable run and the data rate of the system. Beyond the obvious traits such as number of conductors and wire gauge, cable specifications include a handful of less intuitive terms.

Characteristic Impedance (ohms)—A value based on the inherent conductance, resistance, capacitance, and inductance of a cable that represents the impedance of an infinitely long cable. When the cable is cut to any length and terminated with this Characteristic Impedance, measurements of the cable will be identical to values obtained from the infinite length cable. Therefore, termination of the cable with this impedance gives the cable the appearance of being infinite length, allowing no reflections of the transmitted signal. When termination is required in a system, the termination impedance value should match the Characteristic Impedance of the cable.

Shunt Capacitance (pF/ft)—the amount of equivalent capacitive load of the cable, typically listed in a per foot or per meter basis (1 pF/ft = 3.28 pF/m). One of the factors limiting total cable length is the capacitive load. Systems with long lengths benefit from using low capacitance cable.

Propagation velocity (% of c)—the speed at which an electrical signal travels in the cable. The value given typically must be multiplied by the speed of light (c, $3x10^8$ m/s) to obtain units of meters per second. For example, a cable that lists a propagation velocity of 67% gives a velocity of $0.67x3x10^8 = 2.01x10^8$ m/s. The higher the percentage, the smaller the signal delays.

General recommendations for serial cable are listed in Table 3-3.

Table 3-3. Serial Cable Requirements

Impedance	100 Ohms ±20%
Cable capacitance	52.5 pF/m (15.0 pF/ft) at 1 kHz
Propagation Velocity	67.0%
Data Pairs	0.2 mm² (24 AWG) solid bare copper
Signal attenuation	6.0 dB maximum

Recommended Bulk Cable

Woodward recommended cables are compatible with long run lengths and high baud rates. Longer cable lengths than the maximum specified may be possible at lower baud rates with the best cables, but are not supported by the ANSI standards for RS-485.

Shielded Ethernet Category 5 cable is a very good cable selection for RS-485 networks. It will support cable lengths to 900 m (3000 ft) at baud rates up to 115200. Since Ethernet cable is easy to find and is inexpensive, it will often be the cable of choice. Shielded cable must always be used.

Belden 89207 is a 20 AWG low capacitance cable that is also a good choice for RS-485 networks. It is a larger wire size than Ethernet cables and other typical serial cables, so it is better suited for engine wiring and high-speed communications. At maximum baud rate this cable should be limited to 150 m (500 ft) or less. Shielded cable must always be used.

Since Ethernet cables and other typical serial cables have wire sizes smaller than the 18 AWG minimum for the ECU (PCM128-HD) connector, special wiring practices will be necessary for a good crimp.

The RS-485 serial port is used to provide communications between the control and a PC service tool. Figure 3-6 shows an RS-485 communication schematic.

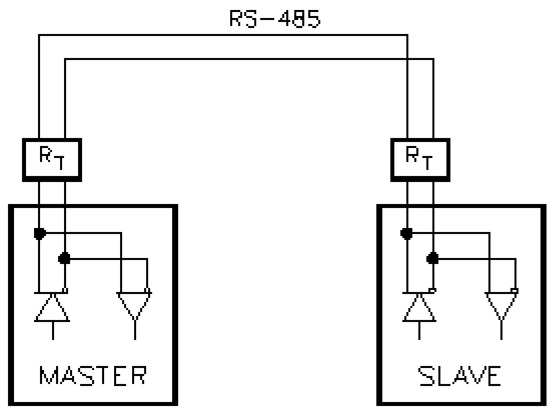


Figure 3-6. RS-485 Standard Link

Termination

For RS-485, termination should be at each end of the cable. The value of each termination resistor should be equal to the cable impedance (typically, 120 ohms for twisted pairs). If termination cannot be located at the end of a cable, it should be placed as close as possible to the end of the cables.

EasySync USB Serial Adapter, Woodward PN 1784-1106

The EasySync USB Serial Adapter is used for connecting the RS-485 or RS-422 communication ports of an engine control module to a PC. The adapter receives its power from the USB port of the PC. It does not need an external power source. This adapter is automatically detected and installed when plugged into the USB port of a PC. If the device is not initially detected and installed, the unit comes accompanied with a Drivers/Installation guide that can be easily installed following the directions below:

Installation for Windows 2000/XP Drivers

1. Plug the USB connector into the USB port on the adapter, and connect the USB connector on the other end of the cable to the host USB port on the PC.
2. A window will open: “Found New Hardware Wizard.”
3. Click “Next.”
4. Select “Search for the best driver for my device”, and click “Next.”
5. Select “Specify a location” and click “Next”. In the “Copy Manufacturer’s file from”, type “D:\USB-COM” where “D” is the location of the PC’s CD-ROM.
6. Windows driver file searches for the device “USB-COM Serial Adapter”.
7. Click “Next” to continue.
8. Windows has finished installing the software. Click “Finish” to complete the first part of the installation.
9. The “Found New Hardware Wizard” appears again, and will complete the installation for the device “USB Serial Port”.
10. Repeat steps (4) to (8) to complete installation.

On the end of the unit with the DB9 connector, there are 4 dip switches that must be configured properly to select the mode of operation. The adapter is capable of converting USB to RS-422 or RS-485.

To configure the device for RS-485 or RS-422, set the dip switches as shown in the following table:

	S1	S2	S3	S4
RS-485	OFF	OFF	ON	ON
RS-422	ON	ON	OFF	OFF

The EasySync adapter jumper settings.

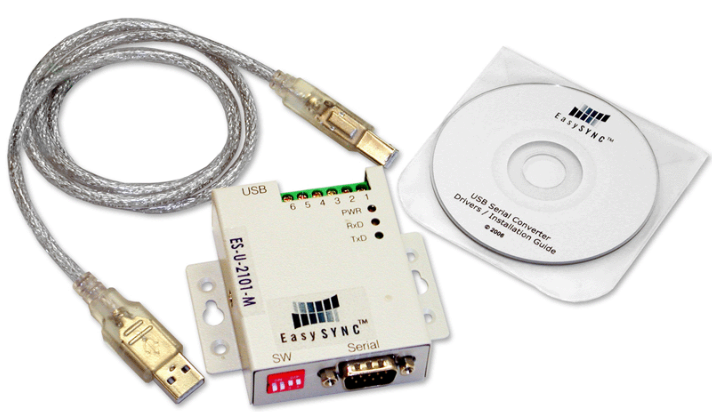


Figure 3-7. EasySync RS-485 to USB Adapter

CAN Communications Ports

The ECU (PCM128-HD) has two CAN ports. The CAN ports are not isolated from each other, or from any of the other circuitry on the PCM128-HD control, i.e., they share a common ground. The internal CAN port is used only for communication with Woodward on-engine hardware. Optional on-engine hardware with CAN communication includes the F-Series ITB/actuator with CAN option, L-Series ITB/actuator with CAN option, and the IC-920/922 ignition control. The external port is used for plant communications, and can be connected to other equipment when applying a CAN isolator or isolated gateway.

Table 3-4. PCM128-HD CAN Specification

Transceiver type	CAN 2.0B
Isolation voltage	None
Baud rates supported	125, 250, 500, and 1000 kbps
Protocols supported	CANopen, SAE J1939

Figure 3-8 depicts typical CAN bus topology.

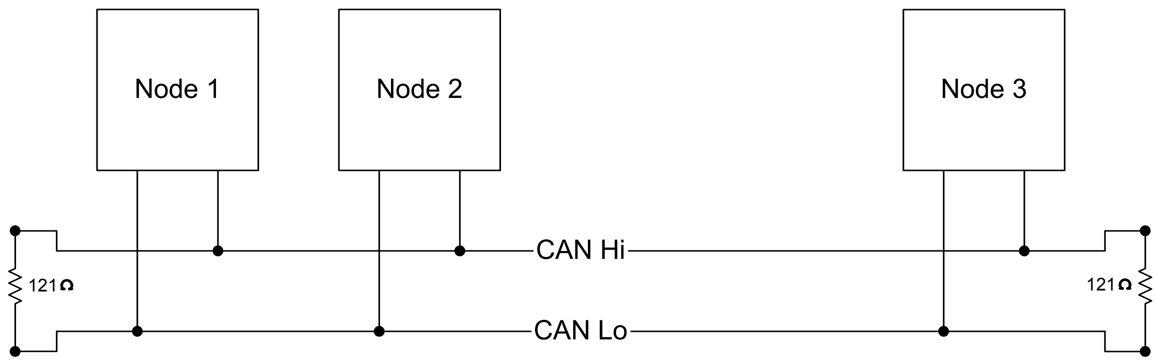


Figure 3-8. CAN Bus Topology

Per ISO 11898-2 the two-wire CAN bus must meet the following criteria:

- A maximum length of 25 m for 1 Mbit/s data rate, 40 m for 250 kbits/s.
- A recommended maximum drop line length of 0 m for 1 Mbit/s data rate, 1 m at 250 kbits/s.
- Characteristic line impedance of 120 Ω
- Nominal line resistance of 70 mΩ/m.
- Nominal specific propagation delay of 5 ns/m.

On both CAN links the SAE J1939 protocol is used and restricted to 250 kbps and the SAE J1939 standard limits wiring distances to 40 meters, when un-isolated controls are connected to the J1939 link.

Recommended Cable

Use only recommended shielded cabling for a CAN network. Correct cable is available from Raychem and many other suppliers providing equivalent cable. “J1939/11” cable is a good example of CAN cable for on engine use.

Part Number	Description
Raychem 2019D0301	Cheminax, J1939-11, 0.75 mm², 120 Ω characteristic impedance, 10.5 pF/ft mutual capacitance, 74% velocity of propagation

The basic cable requirements are listed in Table 3-5. When selecting other cables, be sure they meet these requirements.

Table 3-5. Cable Specification

Data pair impedance	120 Ohms ±10% at 1 MHz
Cable capacitance	12 pF/ft at 1 kHz (nominal)
Capacitive unbalance	1200 pF/1000 ft at 1 kHz (nominal)
Propagation delay	1.36 ns/ft (maximum)
DC Resistance	6.9 Ω / 1000 ft @ 20 °C (maximum)
Data Pair	0.75 mm² – 1.0 mm² corresponds to 20 – 18 AWG, individually tinned, 3 twists/foot
Drain / Shield Wire	0.75 mm² – 1.0 mm² Tinned Copper drain wire inside a braid or foil shield
Signal attenuation	0.13 dB/100 ft @ 125 kHz (maximum)
	0.25 dB/100 ft @ 500 kHz (maximum)
	0.40 dB/100 ft @ 1000 kHz (maximum)

Network Construction

There are a number of different ways to physically connect devices on a CAN network. Woodward recommends that multi-drop networks be constructed using either a "daisy chain" configuration (also called zero length drop line) or a "backbone" with very short drop lines for best performance.

In a daisy chain configuration, wires are run from one device to the next device without drop lines.

In a backbone with stubs configuration, a main trunk line is run between the two devices that are physically farthest apart and have the physically longest cable. Stub lines are run from the intermediate devices to the trunk line. Stubs should be kept as short as possible and may never exceed 6 m (20 ft). It is acceptable to mix both methods on the same network.

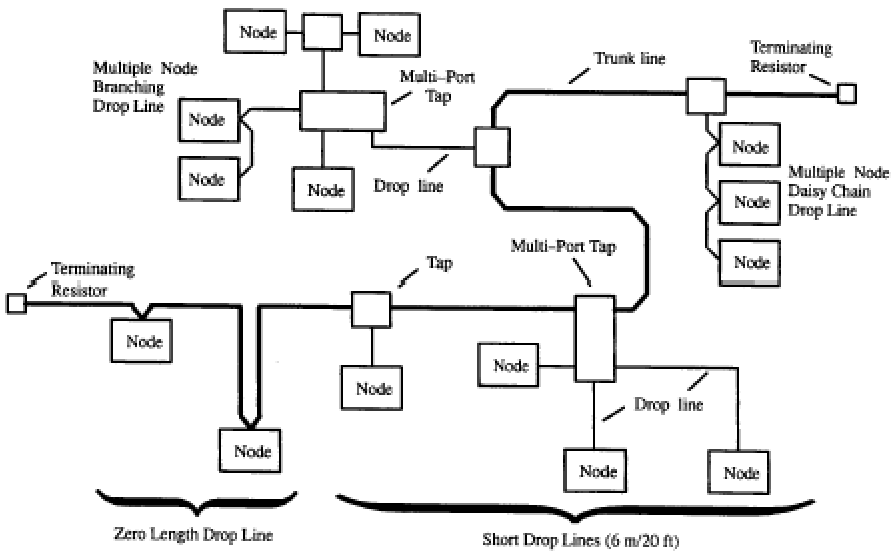


Figure 3-9. CAN System Wiring Example

A daisy chain (zero drop length) connection is not feasible at the PCM128-HD connection due to the sealed connector design. The next best alternative is to use a very short drop line from the trunk into the PCM128-HD. Special ‘T’ connectors (Tap in the diagram above) are available from multiple manufacturers to ease the wiring harness manufacture. Also available from the same manufacturers, are termination resistors that plug directly into the ‘T’ connectors for the network ends.

The PCM128-HD may be used on networks where isolated CAN devices are present. In this case the isolated nodes may have a signal common connection that should be connected to B- for proper referencing with the PCM128-HD. Non-isolated nodes (such as the PCM128-HD) do not have a signal common available for connection. Where the signal common is not available, use the alternate wiring scheme of connecting the CAN ground wire from the isolated nodes to the B- terminal at a non-isolated node. B- is typically the signal reference for CAN if isolation is not provided. Do not connect to B- at more than one location.

Termination

It is necessary to terminate the network to prevent interference caused by signal reflections. Depending on network length, many CAN networks will not operate without proper termination.

In order to allow the possibility of removing and inserting a unit onto a running network, the CAN termination network is not included inside the PCM128-HD control. An external CAN termination network must be provided.

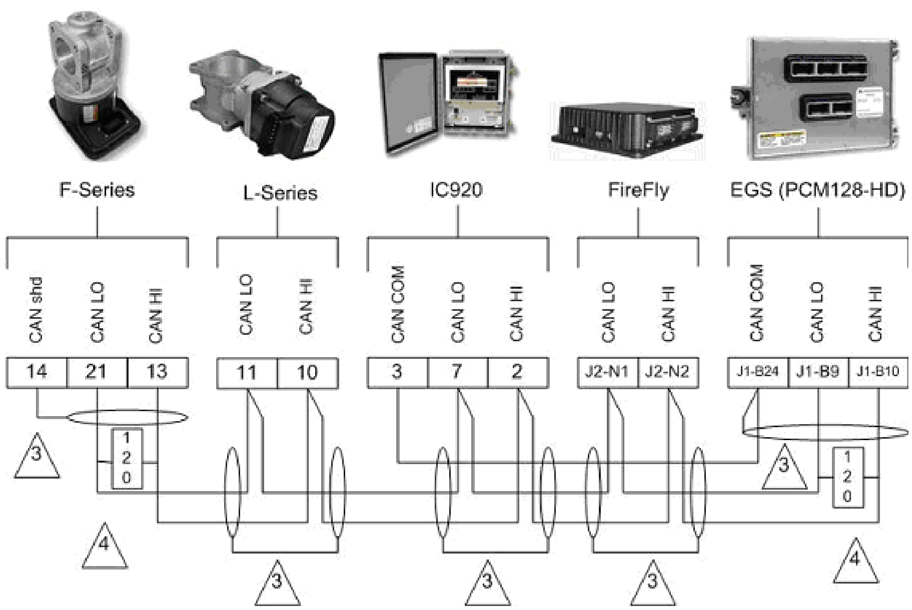
As a rule, no matter how many units are on a network, there should never be more than two network terminations installed. Termination resistors must be installed only for the two units that are at the physical ends of the network. Terminating more than two units can overload the network and stop all communications.

Termination is a simple 121 ohm, ¼ watt, 1% metal film resistor placed between CAN high and CAN low terminals at the two end units, a differential termination. Do not connect the termination resistor to anything besides the CAN high and CAN low wires.

Shielding

Shielded CAN cable is not required between the ECU (PCM128-HD) and any other device(s), but it is highly recommended. Unshielded or improperly shielded cables are likely to cause communication problems and unreliable control operation. Improper shield termination to ground can also cause communication problems and unreliable control operation.

If shielding is used with the E3 CAN wiring, the shield should only be tied at the ECU (PCM128-HD) control ground J1-B24 (Shielding Ground). If the shield is grounded at the other end, it should be through a high-frequency AC ground, i.e., via a 0.01 µF capacitor to chassis-body ground. Figure 3-10 shows an example of a CAN network for the E3 Lean Burn Trim System.



Note 1: Cable per ISO 11898-2:
Maximum length of 40 m. For the J1939 on 250 Kbps.
Ends of the network need to be terminated with 120 ohm resistors
Nominal resistance of line is 70 mΩ/m
Nominal specific propagation delay of 5 ns/m.

Note 2: Maximum length of drop line length of 1 m at 250 kbps
Note 3: Shielding only to be connected to F-Series and E3 sides. The shielding needs to be continued through.
Note 4: Ends of the network need to be terminated with 120 Ohm resistors
Note 5: Termination resistor on ProAct side is mounted inside ProAct. Only a jumper needs to be installed to make the termination active.

Figure 3-10. CAN Network Example

Fuel Trim Valve

⚠WARNING	**EXPLOSION HAZARD—Leak check all gaseous fuel connections. Leaking gaseous fuel can cause explosion hazards, property damage, or loss of life.**

⚠WARNING	**EXPLOSION HAZARD—Do not remove covers or connect/disconnect electrical connectors unless power has been switched off or the area is known to be non-hazardous.** **Substitution of components may impair suitability for Class I, Division 2 or Zone 2.**

⚠WARNING	**Refer to product manuals 26249 and 26237 or 26289 for the L-Series; 26355 for F-Series; 26112 for the ProAct for detailed regulatory compliance information and installation warnings associated with these products.**

⚠WARNING	**External fire protection is not provided in the scope of this product. It is the responsibility of the user to satisfy any applicable requirements for their system.**

⚠WARNING	**Due to the hazardous location listings associated with this product, proper wire type and wiring practices are critical to operation.**

NOTICE	**Do not connect any cable grounds to “instrument ground”, “control ground”, or any non-earth ground system. Make all required electrical connections based on the wiring diagram (Chapter 6).**

⚠CAUTION	**Due to typical noise levels in engine environments, hearing protection should be worn when working on or around the Fuel Trim Valve.**

⚠CAUTION	**The surface of this product can become hot enough or cold enough to be a hazard. Use protective gear for product handling in these circumstances. Temperature ratings are included in the specification section of this manual.**

Trim valve installation instructions are available in the individual component manuals. See the Approved Electronic Parts List (Chapter 7) for available trim valves and corresponding technical manuals.

For assistance with determining the correct valve size and actuator type, please contact Woodward.

Throttle Actuator (F-Series, Flo-Tech, & ProAct Analog)

⚠WARNING	**Refer to product manuals 26355, 04141, and 26147 for the F-Series, Flo-Tech, and ProAct Analog for detailed regulatory compliance information and installation warnings associated with these products.**

⚠WARNING	**EXPLOSION HAZARD—Do not remove covers or connect/disconnect electrical connectors unless power has been switched off or the area is known to be non-hazardous.** **Substitution of components may impair suitability for Class I, Division 2 or Zone 2.**

AVERTISSEMENT	**RISQUE D'EXPLOSION—Ne pas enlever les couvercles, ni raccorder / débrancher les prises électriques, sans vous en assurez auparavant que le système a bien été mis hors tension; ou que vous vous situez bien dans une zone non explosive.** **La substitution de composants peut rendre ce matériel inacceptable pour les emplacements de Classe I, Division 2 ou Zone 2.**

WARNING	**Due to the hazardous location listings associated with this product, proper wire type and wiring practices are critical to operation.**

NOTICE	**Do not connect any cable grounds to "instrument ground", "control ground", or any non-earth ground system. Make all required electrical connections based on the wiring diagram (Chapter 6).**

Throttle Body and Actuator Sizing

Please contact Woodward for correct throttle body and actuator sizing for your application.

Installation Instructions

Complete installation instructions for the F-Series, Flo-Tech & ProAct Analog throttle actuators are available in the individual manuals:

Manual 26355, F-Series Actuator and Integrated Throttle Body
Manual 04141, Flo-Tech Integrated Actuator and Throttle Body
Manual 26147, ProAct Analog Electric Actuator with Integral Driver

Electrical Connections

The mating connector kit for the 14 pin F-Series is part number 8923-1311. The mating connector kit for the 23 pin F-Series is part number 8923-1312. The connectors and terminals can also be purchased from the manufacturer directly:

<u>Tyco Electronics</u>

14 pin connector part number	770680-1
23 pin connector part number	776273-1
Contact part number	770854-3

The mating connector kit for the 75 mm Flo-Tech is part number 8923-371. The connectors and terminals can also be purchased from the manufacturer directly:

<u>Delphi Packard Electric</u>

Connector part number	12020926
Contact part number	12089188
Wire seal part number	12015323
Sealing plug part number	12010300

The mating connector for the ProAct Analog is Mil Spec MS3106F18-9S, which is available from Woodward as a finished cable part number 5417-729 in various lengths. The connector can also be purchased from the manufacturer directly:
ITT Cannon
Connector part number CA3106F18-9S-F80-A232
See the control wiring diagram in Chapter 6 for complete wiring information.

Supply Voltage

The supply voltage during normal operation must be 18 to 32 V, measured at the throttle actuator connector. Follow the supply power wiring requirements that are specified in the respective F-Series, Flo-Tech & ProAct installation and operation manuals.

CAN Termination
Follow the CAN termination instructions in the section above in this chapter, titled *CAN Communications Ports*.

Shielded Wiring
See the section above in this chapter, titled *CAN Communications Ports*, for recommended shielding practices.

14 = CAN Shield
The CAN Shield can be used to terminate the shield of the CAN wiring. Internally, this pin is connected to the F-Series case through a capacitor.

CAN Hi and Lo
13 = CAN high in
21 = CAN low in
14 = Shield

Pins 13 and 21 are the CAN communication wires. Make sure that the correct cable is used for connection to the CAN terminals (SAE J1939/11). Follow the CAN shielding instructions in the section above in this chapter, titled *CAN Communications Ports*.

Voltage Level: 5 V
Isolation: 1000 Vrms (optically decoupled)
Type: The F-Series with CAN supports CAN 2.0B.
Baud Rate: Configurable from 250 K to 1 Meg, however the J1939 standard of 250 Kbps is used on the E3 control.

Service Tool Communications

Please consult the F-Series Installation and Operation manual, publication 26355, for instructions on connection and use of the F-Series service tool.

Engine Speed Sensor

If a variable reluctance magnetic pick-up sensor (MPU) input is used to detect engine speed, it is connected to the PCM128-HD as shown below. Shielded wire for the speed sensor inputs is recommended, but is not required unless problems are encountered due to noise on the signal. Connect the shield to J1-B24 (SHIELDING GROUND). Make sure the shield has continuity the entire distance to the speed sensor, and make sure the shield is insulated from all other conducting surfaces. If shielded wire is not used, then a twisted wire pair is the next best alternative.

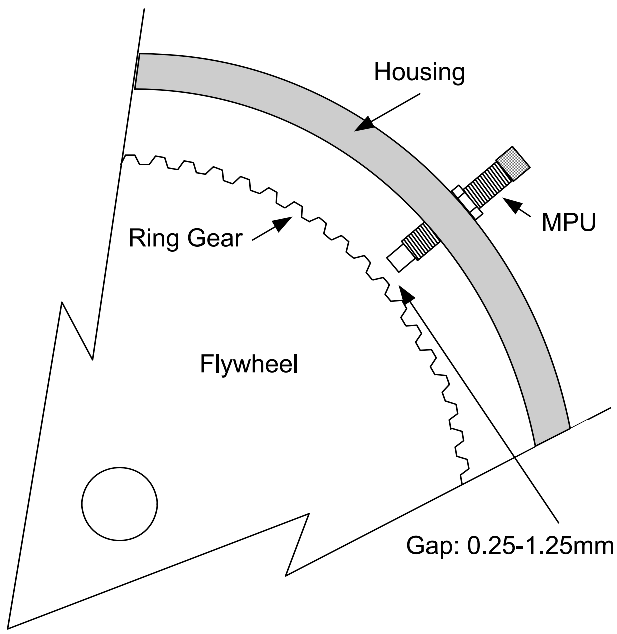


Figure 3-11. Magnetic Pickup Mounting in Flywheel Housing

The following installation guidelines should be observed:

- Install the magnetic pickup (MPU) on the outside diameter of the flywheel gear, either through the housing or a bracket. Usually the MPU will be located in the flywheel housing of the engine.
- Set the gap between the MPU and the flywheel gear between 0.25 and 1.25 mm.
- Connect the MPU wires to the E3 Lean Burn Trim control, terminals J1-A2 and J1-A13.
- Minimum voltage of 1.5 to 2 Volt top-top is needed for proper signal detection.

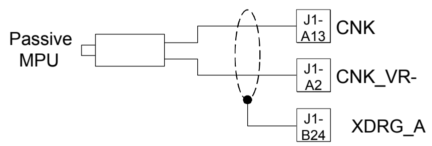


Figure 3-12. Magnetic Pickup Wiring – Speed sensor

Optionally, an active proximity probe can be used. Proximity sensor wiring is shown in Figure 3-13. For more information refer to the PCM128-HD hardware manual (document 26309).

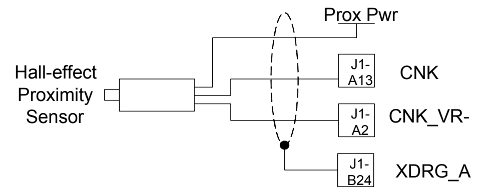


Figure 3-13. Proximity Sensor Wiring – Speed sensor

Engine Position Sensor

If the E3 Lean Burn Trim system is used in combination with Smart Coils, a camshaft position sensor is required. The camshaft sensor signal, in combination with the engine speed sensor, is used to determine engine position.

The cam trigger disk can be a single tooth, or an N+1 type (Figure 3-14).

For other camshaft trigger disk configurations, please contact Woodward.

Shielded wire for the engine position sensor inputs is recommended, but is not required unless problems are encountered due to noise on the signal. Connect the shield to J1-B24 (SHIELDING GROUND). Make sure the shield has continuity the entire length to the speed sensor, and make sure the shield is insulated from all other conducting surfaces. If shielded wire is not used, then a twisted wire pair is the next best alternative.

The following MPU installation guidelines should be observed:

- Set the gap between the MPU and the trigger disk between 0.25 and 1.25 mm.
- Connect the MPU wires to the E3 Lean Burn Trim control, terminals J1-A20 and J1-A31.
- Minimum voltage of 1.5 to 2 Vrms is needed for proper control.

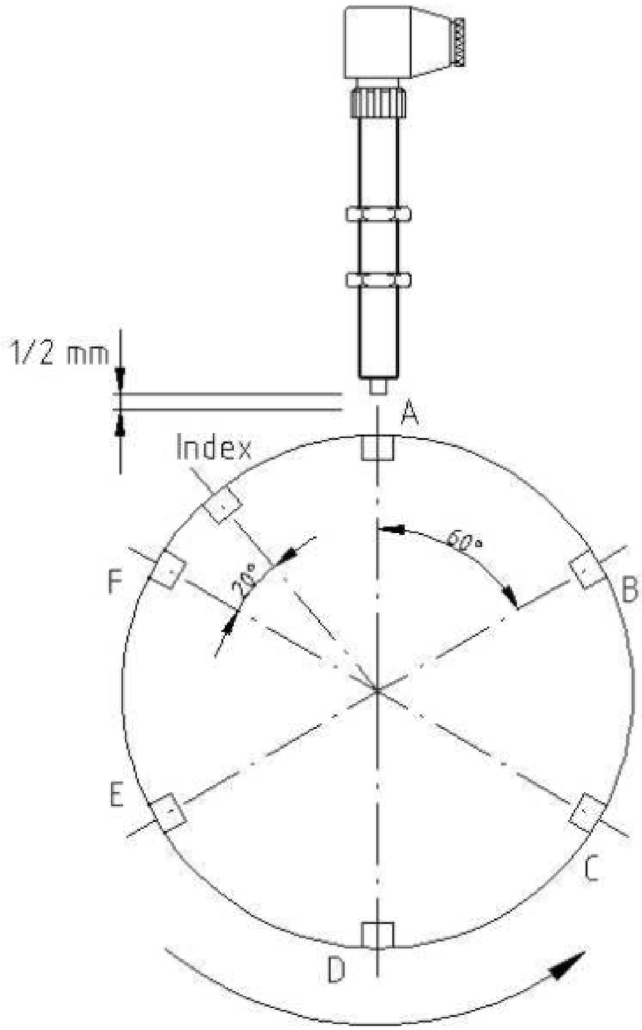


Figure 3-14. N+1 Trigger disk (6-cylinder engine shown)

Engine position MPU wiring is shown in Figure 3-15.

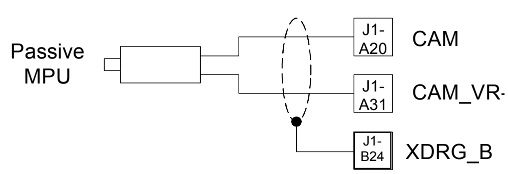


Figure 3-15. Magnetic Pickup Wiring – Position Sensor

Engine position proximity sensor wiring is shown in Figure 3-16. For more information refer to the PCM128-HD hardware manual (document 26309).

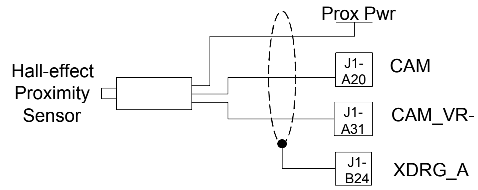


Figure 3-16. Proximity Sensor Wiring – Position Sensor

> **WARNING**
>
> **To prevent possible serious injury from an over speeding engine, make sure the control is properly programmed with the correct gear pattern. Refer to Table 3-6 for information on gear tooth pattern selection. Improper pattern selection could cause engine damage.**

Manifold Absolute Pressure Sensor (MAP)

The standard Manifold Absolute Pressure (MAP) Sensor for the E3 system is PN 6910-314. The MAP sensor is used to indicate engine load, calculated in a percentage of maximum MAP.

Mount the MAP sensor at a position where only minor ambient temperature changes occur during normal operation. The pressure connection of the MAP sensor should be after the throttle valve, on the topside of the manifold to avoid oil, water or dirt entering the sensor or hose. Do not mount the pressure connection close to an intake port, directly after the throttle, or at the dead end of the manifold to avoid erratic readings due to pulsations or strong turbulence. Place the MAP sensor higher than the sample point. Mount the tube or hose continuously rising to avoid trapping oil, water or dirt in the hose or tube.

Connect the wires of the MAP sensors to terminals J1-A30 (MAP_1), and transducer ground.

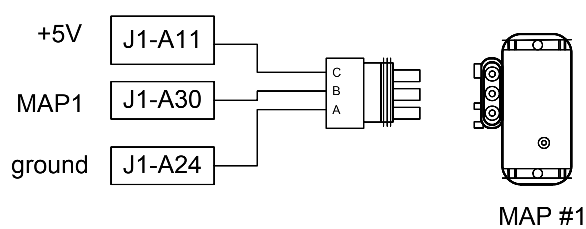


Figure 3-17. Manifold Pressure Sensor Wiring

For the use of customer-provided or optional Woodward-provided MAP sensors, please contact Woodward.

Manifold Air Temperature Sensor (MAT)

The standard Air Temperature Sensor (MAT) Sensor for the E3 system is PN DL08041301. The MAT sensor is used in the calculation of engine load, based on air density in the manifold. Install the Manifold Air Temperature (MAT) sensor in the inlet manifold of the engine. Connect the two wires of the sensor element to terminals J1-A10 and transducer ground (see “E3 Wiring Diagram”).

It is important that the sensing element in the tip of the sensor measures the temperature that represents a good average of the flow. When the tip of the sensor is too close to the wall, the influence of the temperature of engine components affects the measurement.

The PT-100 MAT sensor used with the legacy product E3-01 is not compatible with the E3. The MAT sensor should be an NTC thermistor type. For the use of customer-provided or optional Woodward-provided MAT sensors, please contact Woodward.

TMAP Sensor

For small engines a combined TMAP sensor is available. For large engines (with relatively thick intake manifold castings) the tip of this sensor will not protrude far enough into the intake manifold, so the influence of the temperature of engine components will affect the measurement of manifold air temperature. Figure 3-18 shows TMAP sensor wiring. For more information refer to the TMAP sensor manual, document 82689 (this document has limited distribution – to receive a copy, please contact Woodward).

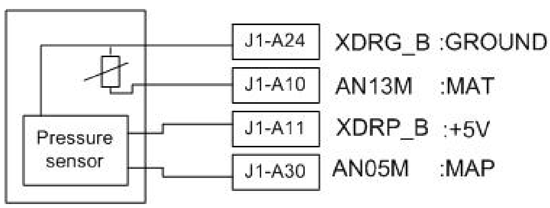


Figure 3-18. Bosch TMAP Sensor Wiring

Engine Coolant Temperature Sensor (ECT)

The Engine Coolant Temperature (ECT) sensor should be installed in the engine water jacket. The two wires of the sensor element should be connected to terminals J1-C15 and transducer ground. For more information, refer to the control wiring diagram in Chapter 6.

Generator Power Input

This input is configured for a load transducer (kW) or torque signal connected J1-A29 and transducer ground.

Woodward recommends real power sensors that are powered separately from the generator so that a failed load signal is not detected during shutdown. The signal should be 0.5 to 4.5 Vdc so that a failed signal can be detected. Measurement of all three phases is required.

An analog transducer is preferred (e.g. Woodward UMT1). A transducer needs a maximum response time of approximately 250 ms for a 0–90% change in load. An accurate signal and update time will reduce the emission excursions and minimize closed loop error when operating in GQCL mode.

A signal from a PLC is not preferred. If a PLC signal is used, then a galvanic isolator must be mounted between E3 input and PLC output.

Remote Reference

The remote reference input (speed or load) is connected to J1-A25 and transducer ground. The signal should be a 0.5 to 4.5 Vdc signal, so that loss of signal can be detected.

Galvanic isolators are required in cases where the signal is shared with other applications and to eliminate ground loop problems.

Speed Reference Bias, Synchronizer or Load Control

The speed reference bias signal is wired to J1-A16 and transducer ground. This bias signal is added directly to the speed setpoint. The input signal must be configured with a null point, such as 2.5 Vdc. The null point voltage corresponds to a bias of 0 rpm.

Lambda (UEGO) Sensor

The UEGO (Universal Exhaust Gas Oxygen) sensor measures the oxygen content of the exhaust mixture. Bosch LSU 4.2 UEGO sensor wiring is shown in Figure 3-19. For more information, see the Bosch LSU 4.2 UEGO sensor application manual, document 26345 (to obtain a copy, please contact Woodward).

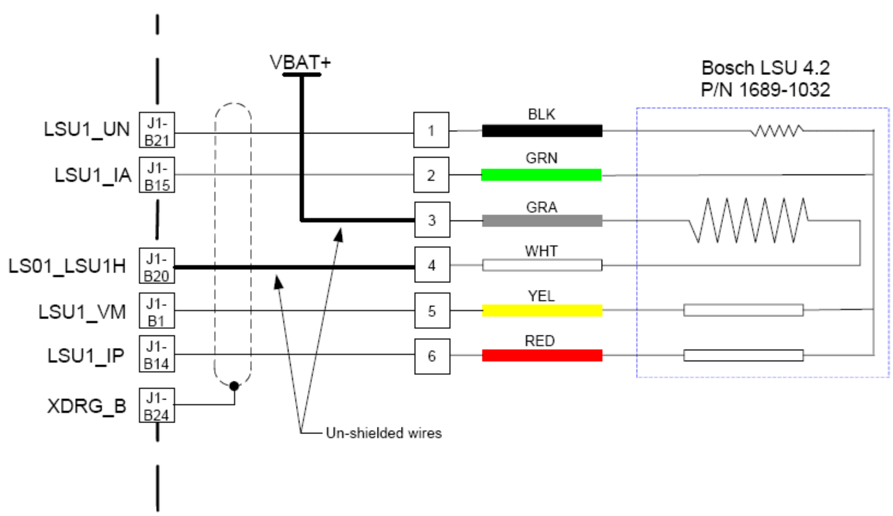


Figure 3-19. Bosch LSU Sensor Unit Wiring Diagram

IMPORTANT **It is recommended that the wires from the UEGO sensor(s) to the E3 control be shielded to reduce the levels of EMI.**

Galvanic Isolation

To avoid problems with analog connections to the ECU, isolators should be used. These separate the analog input from the ECU galvanically. These devices require a power supply, which is also isolated from the input and the output of the isolator.
Phoenix supplies configurable isolating amplifiers like MINI MCR-SL-UI-UI(-SP) (–NC). On the input and output side, the standard signals 0–20 mA, 4–20 mA, 0–10 V, 2–10 V, 0–5 V, or 1–5 V are available, electrically isolated. The DIP switch accessible on the side of the housing allows the configuration of the input and output signal ranges. The voltage supply (19.2–30 Vdc) can either be provided via connecting terminal blocks "3"/"4" or "7"/"8" of the modules, or together, via the DIN rail connector.

IC-920/-922 Ignition Module

⚠WARNING

EXPLOSION HAZARD—Refer to product manual 26263 for the IC-920/-922 Ignition Module for detailed regulatory compliance information and installation warnings associated with this product.

⚠WARNING

EXPLOSION HAZARD—Do not remove covers or connect/disconnect electrical connectors unless power has been switched off or the area is known to be non-hazardous.

Substitution of components may impair suitability for Class I, Division 2 or Zone 2.

⚠WARNING

Due to the hazardous location listings associated with this product, proper wire type and wiring practices are critical to operation.

NOTICE

Do not connect any cable grounds to “instrument ground”, “control ground”, or any non-earth ground system. Make all required electrical connections based on the wiring diagram (Chapter 6).

Optional high energy capacitive discharge ignition functionality for this system is provided by the IC-920/-922 ignition module. The IC-920/-922 is shown in Figure 3-20. This module communicates with the E3 controller over the internal J1939 network.

The IC-920/-922 is a modern high-energy capacitance discharge ignition system. The system consists of a 16-bit CPU and other CPU related peripherals, sensor signal conditioning circuitry, a high voltage power supply, and 20 outputs (24 outputs are optional, for 12 cylinder engines with two coils per cylinder). The system can be configured for two cylinders up to 20 cylinders. The E3 system CD includes all the required software needed to configure the Ignition control for any type of industrial engine. All user programming/configuration is accomplished using IC-900 Series Service Tool software residing on a PC (personal computer). This software is included on a CD-ROM supplied with each IC-920/-922 system.

The IC-920/-922 uses information provided by 3 required sensors to precisely determine the correct crank angle for firing each output (speed sensor, TDC sensor and phase sensor).

Figure 3-20. IC-920/922 Ignition Control

During operation, the IC-920/-922 continuously monitors the status of the system by verifying proper information from all timing sensors and proper operation of the primary ignition circuit. Depending on the severity of a detected fault, the unit will either shut down or warn the operator via integral warning lamps as well as via fault signals communicated over the J1939 network to the E3 controller, which will in turn activate the corresponding alarm output.

The IC-920 is a CD system that stores a maximum of 180 mJ (at 100% energy setting) while the IC-922 stores a maximum of 360 mJ (at 100% energy setting). The IC-920 is the standard E3 system option; the IC-922 can be selected when higher ignition energy is required.

The IC-920/-922 module (part number 8408-0702 or 8408-0724) is integrated with the E3 System by connecting it to the Engine CAN bus (see Figure 3-8 or the control wiring diagram in Chapter 6). Control and diagnostic information is communicated between the units is through this bus connection.

For further description of IC-920/-922 functionality in the E3 system, see *Ignition Control (IC-920/922 or Smart Coils)* in Chapter 2 and *Commissioning of the IC-920/922 Ignition* in Chapter 4.

For complete information on the IC-920/-922, see the IC-920/922 Installation and Operation Manual (document 26263).

Heavy Duty Smart Coils

Optional inductive coil ignition functionality for this system is provided by Woodward Heavy Duty Smart Coils, shown in Figure 3-21. The PCM128-HD is capable of controlling the primary current to the Smart Coils to obtain the optimum secondary voltage potential and spark energy for various running conditions. The Smart Coil has an integrated driver circuit that eliminates the need for a separate ignition control module. The driver circuit receives a pulse from the PCM128-HD at the Smart Coil's Electronic Spark Timing (EST) input to control spark output. The PCM128-HD is capable of detecting if a Smart Coil is connected to the EST output.

For complete information, see the Smart Coil Application/Troubleshooting Manual, document 26313 (this document has limited distribution – to receive a copy, please contact Woodward).

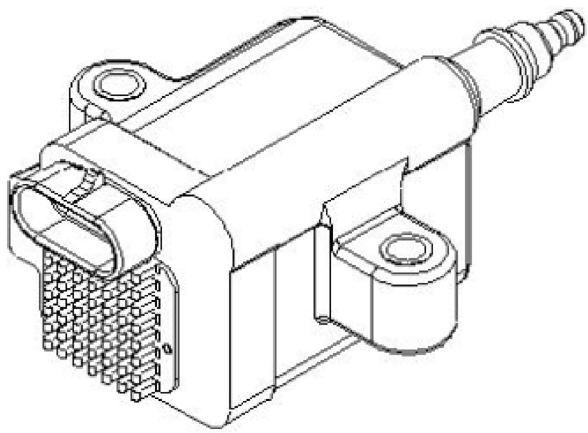


Figure 3-21. Woodward Heavy Duty Smart Coil

External CAN Bus (J1939)

There is an external J1939 CAN bus for transmission of engine and system data to other plant devices. The available data are shown in Figure 3-22.

As the external CAN bus circuit is not isolated, isolation of external devices is required to avoid ground loops and communication failure.

Reader Write by External Control	PGN	Parameter Group Label	PGN Length	Transmission Rate	pos	SPN length	SPN	J1939 Standard Name	Resolution	Offset	Units
Read	61444	Electronic Engine Controller 1	8	500	4-5	16	190	Engine Speed	0.125 rpm/bit	0	rpm
Read	61443	Electronic Engine Controller 2	8	500	3	8	92	Engine Percent Load At Current Speed	1 %/bit	0	%
Read	65253	Engine Hours, Revolutions	8	500	1-4	32	247	Engine Total Hours of Operation	0.05 hr/bit	0	Seconds
Read	65283	Misfire	8	500	1-2	16	516105	Misfire	0.001 RPM/SEC^2/bit	0	RPM/SEC^2

Read	65262	Engine Temperature 1	8	500	1	8	110	Engine Coolant Temperature	1 deg C/bit	-40	C
Read	65271	Vehicle Electrical Power 1	8	500	7-8	16	158	Keyswitch Battery Potential	0.05 V/bit	0	Volts
Read	65262	Engine Temperature 1	8	500	3-4	16	175	Engine Oil Temperature 1	0.03125 deg C/bit	-273	C
Read	65263	Engine Fluid Level/Pressure 1	8	500	4	8	100	Engine Oil Pressure	4 kPa/bit	0	kPa
Read	61443	Electronic Engine Controller 2	8	500	2	8	91	Accelerator Pedal Position 1	0.4 %/bit	0	%
Read	65153	Fuel Information 2 (Gaseous)	8	500	5	8	1442	Engine Fuel Valve 1 Position	0.4 %/bit	0	%
Read	65270	Intake/Exhaust Conditions 1	8	500	2	8	102	Engine Intake Manifold #1 Pressure	2 kPa/bit	0	kPa
Read	65270	Intake/Exhaust Conditions 1	8	500	3	8	105	Engine Intake Manifold 1 Temperature	1 deg C/bit	-40	C
Read	65193	Exhaust Oxygen 1	8	500	3-4	16	1118	Engine Desired Exhaust Oxygen	0.0025 %/bit	0	%
Read	65193	Exhaust Oxygen 1	8	500	5-6	16	1119	Engine Actual Exhaust Oxygen	0.0025 %/bit	0	%
Read	65193	Exhaust Oxygen 1	8	500	7	8	1695	Engine Exhaust Gas Oxygen Sensor Fueling Correction	1 %/bit	-125	%
Read	65312	Proprietary B	8	500	1	8	516096	Manual Bias Bank 1 Total	1 %/bit	-125	%
Write	65313	Proprietary B	8	500	1.1	2	516101	Manual Increment Rich Bank 1	1%/bit	0	
Write	65313	Proprietary B	8	500	1.3	2	516102	Manual Increment Lean Bank 1	1%/bit	0	
Read	61443	Electronic Engine Controller 2	8	500	5	8	29	Accelerator Pedal Position 2	0.4 %/bit	0	%
Read	65153	Fuel Information 2 (Gaseous)	8	500	6	8	1443	Engine Fuel Valve 2 Position	0.4 %/bit	0	%
Read	64976	Intake/Exhaust Conditions 2	8	500	4	8	3562	Engine Intake Manifold #2 Pressure	2 kPa/bit	0	kPa
Read	65189	Intake Manifold Information 2	8	500	1	8	1131	Engine Intake Manifold 2 Temperature	1 deg C/bit	-40	C
Read	65312	Proprietary B	8	500	3-4	16	516098	Engine Desired Exhaust Oxygen 2	0.0025 %/bit	0	%
Read	65312	Proprietary B	8	500	5-6	16	516099	Engine Actual Exhaust Oxygen 2	0.0025 %/bit	0	%
Read	65312	Engine Exhaust Bank 2 O2 Fuel Trim	8	500	7	8	516100	Long-term Fuel Trim - Bank 2	1 %/bit	-125	%
Read	65312	Proprietary B	8	500	2	8	516097	Manual Bias Bank 2 Total	1 %/bit	-125	%
Write	65313	Proprietary B	8	500	1.5	2	516103	Manual Increment Rich Bank 2	1%/bit	0	
Write	65313	Proprietary B	8	500	1.7	2	516104	Manual Increment Lean Bank 2	1%/bit	0	

Figure 3-22 External CANbus Address List (J1939)

easYgen-3100/3200/3400/3500

As part of the E3 System in a generator application, the easYgen-3100/3200/3400/3500 power management module can be connected to the plant CAN bus (see the control wiring diagram in Chapter 6). Control and diagnostic information between the units is exchanged via this bus connection,

For a full description of easYgen functionality, setup and configuration in the E3 system, see Chapters 3 and 4. For complete installation information, see the easYgen-3000 installation manual (document 37223).

Installation Checkout Procedure

When hardware installation is complete, observation of the following checkout procedures is recommended before commissioning is started.

1. Visual inspection
   A. Check for correct wiring in accordance with the control wiring diagram, (see Chapter 6 and individual component manuals as required).
   B. Check for broken terminals and loose terminal screws.
   C. Check for proper connections to the control connectors.
   D. Check the speed sensor(s) for visible damage. If the sensor is a magnetic pickup, check the clearance between the gear and the sensor, and adjust if necessary. Clearance should be between 0.25 and 1.25 mm (0.010 and 0.050 inch) at the closest point. Make sure the gear runout does not exceed the pickup gap.
2. Check for proper ground connection between the control and the engine chassis.
3. Check the shielding on CAN links has been correctly installed, following control wiring diagrams.
4. Check that installed fuses are in accordance with wiring diagram and with wiring used.

Chapter 4.
Commissioning

General

Commissioning can begin once all system hardware has been installed. Commissioning is performed using the ToolKit HMI.

When available, a settings file for an existing engine of the same type can be used and uploaded to the E3 controller. This makes the commissioning easier, however it is important to remember that when uploading a settings file, all previous settings will be overwritten. All settings and sensor calibrations should be checked to ensure they are valid for the new engine.

Toolkit Service Tool

The EGS Toolkit Service Tool communicates with the control through an RS-485 connection to the communication port.

Follow these steps to communicate with the control:

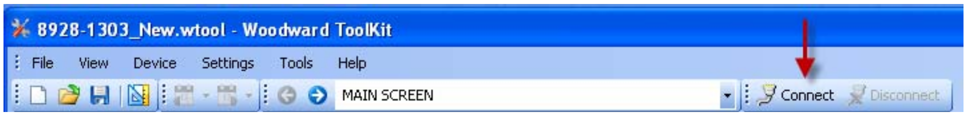
Step 1:
Download the EGS ToolKit Service Tool software and the ToolKit software from www.woodward.com.

Step 2:
Connect a serial cable from the computer to the RS-485 port on the EGS.

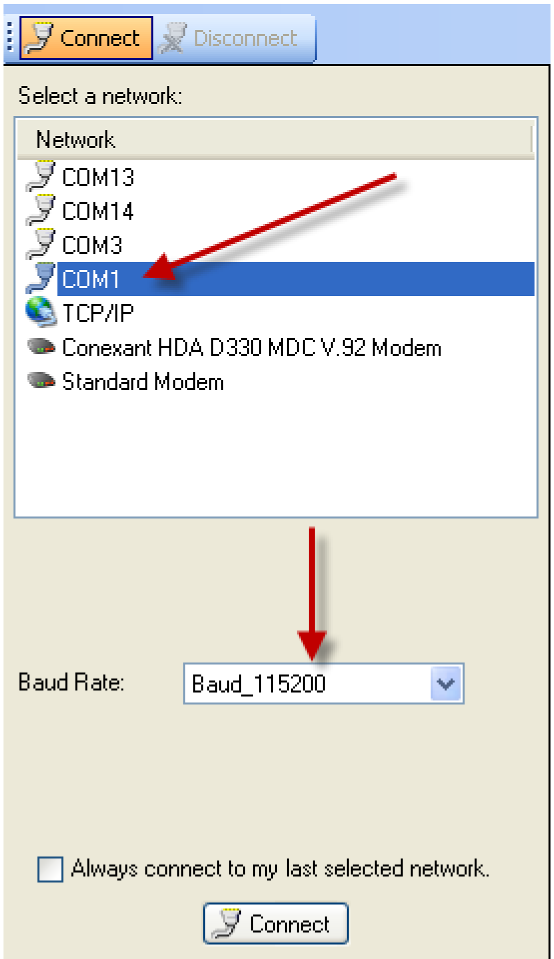
Assure that you have installed the proper drivers on your computer to support the USB to Serial converter.

Step 3:
Open the ToolKit software and select File \ Open the .wtool file.

Click on Connect.



Select the correct communication port that your serial cable is connected to on your computer and the baud rate is set to “Automatically Detect.”



The Service Tool should connect and should start receiving information data.

If it does not connect; verify the following:

1. That the cable is connected to the correct port on your computer.
2. That the cable was connected after opening the .wtool.

ToolKit (Professional)

To be able to design and build pages, you must purchase a software license (ToolKit Professional).
Woodward part number: 8928-5016

The ToolKit professional application is the same application as ToolKit standard, you don't have to install different software. You need to authorize the software under the 'Tools' menu.

Changing Table Values in ToolKit HMI

The values in the 2D and 3D tables in toolkit can be changed by clicking on the value with the mouse and entering a new value. The value entered is used in the control after the left mouse button is clicked or the enter key is pressed. To make it easier to manipulate several values, or even a whole table at once, the cells to be edited are highlighted using the mouse and then the right mouse button is clicked. In the popup window there are different options to modify the table values.

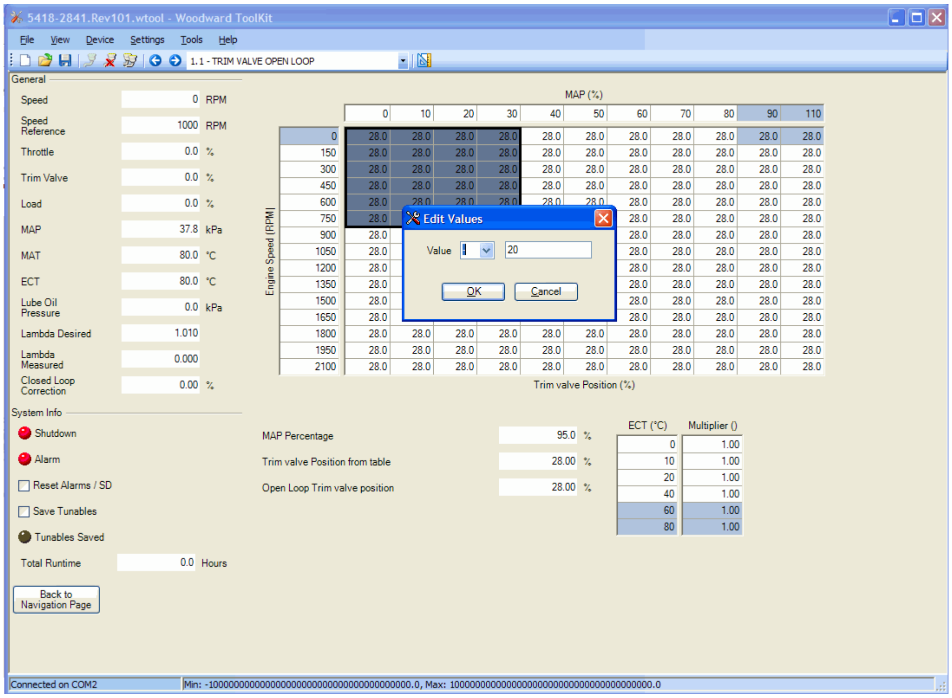


Figure 4-1. Editing Several Values in 2D and 3D Tables

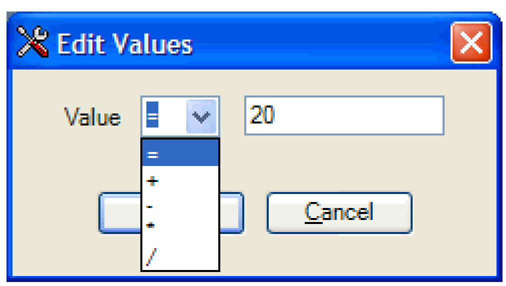


Figure 4-2. Selecting an Operator to Modify Table Values

Toolkit Trend Chart Component

The Toolkit Trend Chart Component allows you to monitor values in a trend window. See Common Component States in Toolkit Help for Trend Chart states.

Monitoring Values
The Trend Chart component displays multiple values in a trend with the parameter name.
To start monitoring values using the Trend Chart component, left mouse click on the **Start** button.
To stop monitoring values using the Trend Chart component, left mouse click on the **Stop** button.

Changing Trend Chart Properties

You can modify the properties of the plots and the Trend Chart component by clicking the **Properties** button on the Trend Chart component. Some of the properties you can change include the Time Span and Sample Rate of the chart as well as the Scale and Color of each individual plot.

Removing a Plot from the Trend Chart

There are several methods to remove a plot from the Trend Chart. Choose a method below to remove a plot. Once a plot has been removed, you will not be able to recover the plot. You can only re-add the parameter to the Trend Chart by dragging it from the list of parameters in the Design Tools window and dropping it on the Trend Chart component.

Method 1:

1. In Run Mode, **right-click** on the plot to remove.
2. Select **Remove Plot** from the pop-up menu.

Method 2:

1. In Run Mode, click on the **Properties** button.
2. In the Trending Properties dialog, select the plot to remove and click on the **Remove Plot** button.
3. Close the Trending Properties dialog.

Method 3:

1. In Design Mode, select the **Trend Chart** component.
2. Select the **Properties...** tab of the **Design Tools** window.
3. Click the **...** button adjacent to the **Plots** property.
4. In the Plot Properties dialog, select the plot to remove and click on the **Remove Plot** button.
5. Close the Plot Properties dialog.

Exporting Trend Values

The Trend Chart component allows you to export the trend values that are currently in the visible trend chart to a .csv file for inspection by other programs. To export trend values:

1. Capture the trend in the trend chart window.
2. Right mouse click on the **Export...** button.
3. Select the file name to be saved in the **Save Dialog**.
4. Select the **Save** button on the **Save Dialog**.

Trend on the Fly

ToolKit allows you to trend any value even if a trend chart is not part of your tool. To trend on the fly:

1. Connect to the device.
2. Right mouse click on the component containing the parameter value you wish to trend.
3. Left mouse click the **Add To Trend** pop-up menu item.
4. The **Trending** window will open with the parameter value you selected.
5. To add additional parameters to the trend repeat steps 3 and 4 for each parameter.

I/O Commissioning

I/O commissioning is performed by entering the correct settings for each sensor and actuator used. The HMI screens for these devices are organized under the heading I/O on the navigation screen. The alarm levels are configured by the user, at the top of each screen (Minimum and Maximum voltage levels). These voltage levels are used to detect a sensor/wiring failure. Lower down on the screen, the transfer function table is populated by the user to configure the relationship between the sensor input voltage and the engineering units used in the control.

MAP_1 and Lube Oil Pressure-signal

Figure 4-3 shows the HMI user settings for MAP_1 and Lube Oil Pressure. The default settings apply to the standard Woodward supplied sensors. When other transmitters are used, the applicable calibration data should be entered.
To enable a lube oil pressure sensor in the system, the box beside "Use Lube Oil Pressure sensor" must be checked.

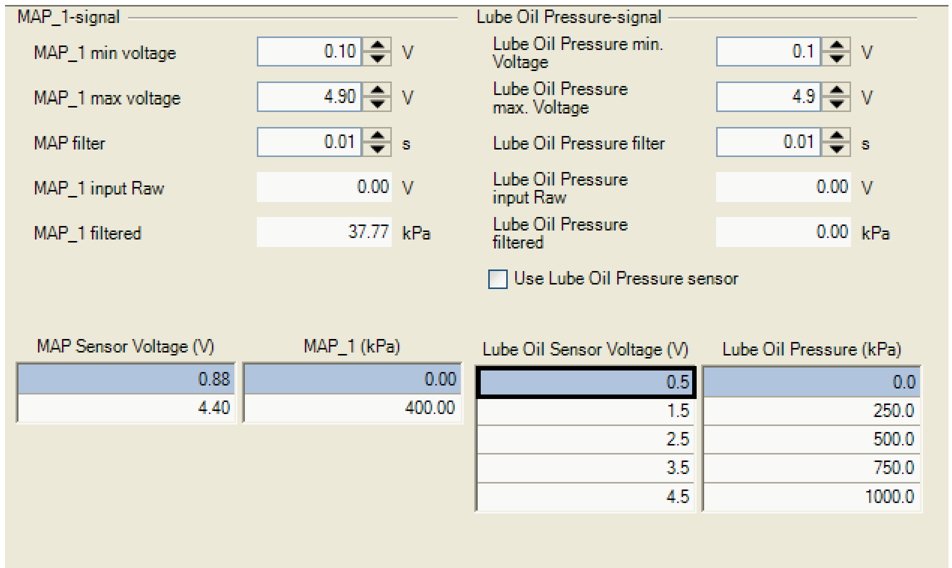


Figure 4-3. HMI Settings for MAP and Lube Oil Pressure (HMI Screen 4.1)

MAT_1 and ECT

Figure 4-4 shows the HMI user settings for MAT_1 and ECT. The MAT_1 sensor is required and the ECT sensor is optional. The default settings apply to the standard Woodward supplied sensors as described in Chapter 2 under *MAT Signal Input* and *ECT Signal Input*, respectively.

"MAT @ sensor failure" is a user specified value which is used by the logic if the sensed MAT sensor voltage is out of range. It is suggested to enter the value normally observed at full load operation.

"ECT @ sensor failure" is a user specified value which is used by the logic if the ECT sensor voltage is out of range. It is suggested to enter the value normally observed at full load operation.

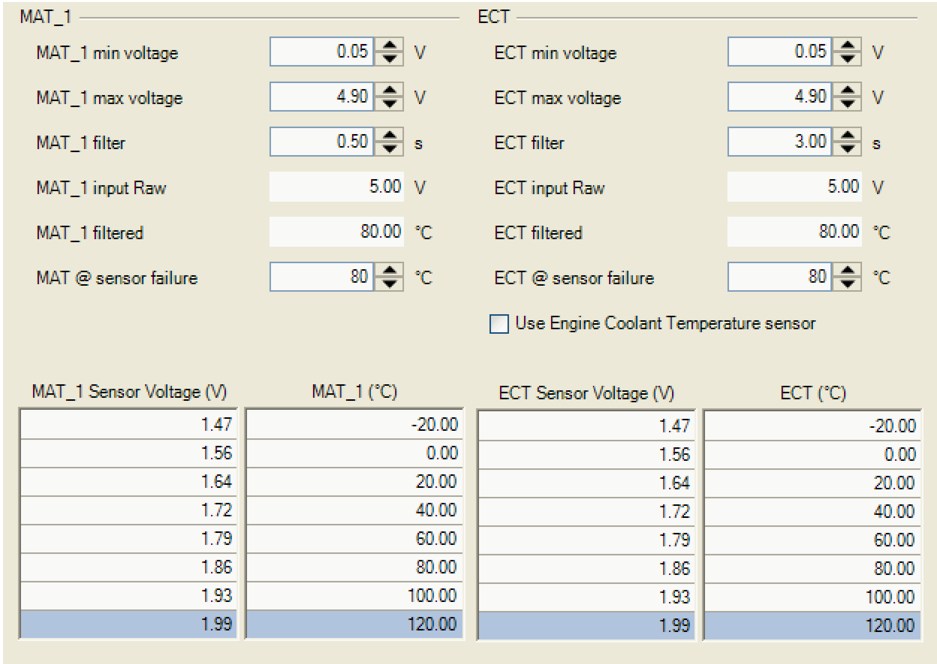


Figure 4-4. HMI Settings for MAT_1 and ECT (HMI Screen 4.3)

Remote Speed/Load reference and Speed Bias
Figure 4-5 shows the HMI user settings for Remote Speed/Load Reference and Speed Bias.

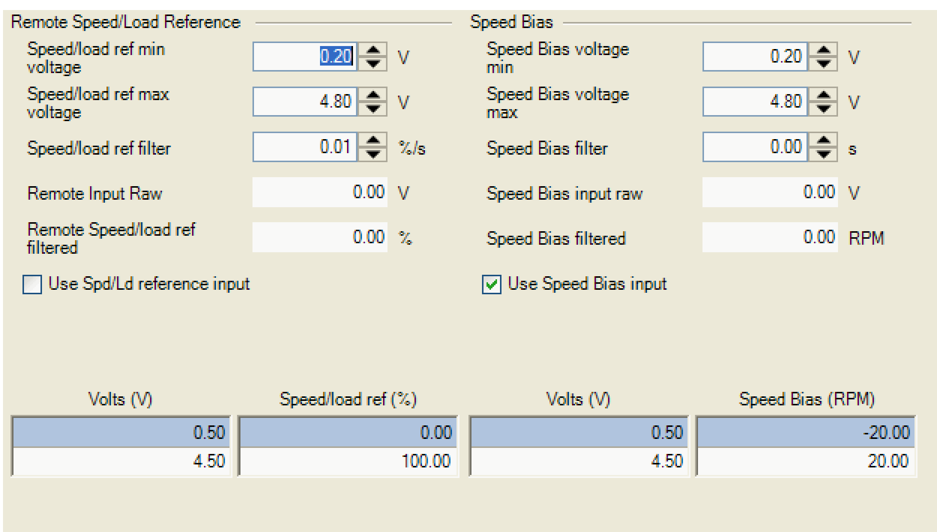


Figure 4-5. HMI Settings for Remote Speed/Load Reference and Speed Bias (HMI Screen 4.5)

Remote Speed/Load Reference
The remote reference is an optional input. It can be used as speed reference, or in the case of a generator application, either a load or speed reference, depending on the status of the generator breaker and the utility breaker inputs.

Speed Bias – Generator application only
This is the value that is directly added to the speed reference. It can be used as synchronizer input and as load sharing input. The input type is a standard 0–5 V voltage input.

TPS_1 (Throttle Position)
Figure 4-6 shows the HMI user settings for the throttle position signal. The TPS_1 (Throttle Position) signal can be enabled by the user if a feedback signal is desired to monitor the actual position of the mixture actuator. To enable this signal, check the box beside "Use TPS_1 signal". There is no position error check done on this signal during normal operation. In a detected engine overpower situation (see *Engine Overpower Protection* in Chapter 2), if this signal is available and valid, a position error check is then done which will trigger a shutdown when the error exceeds the shutdown threshold.

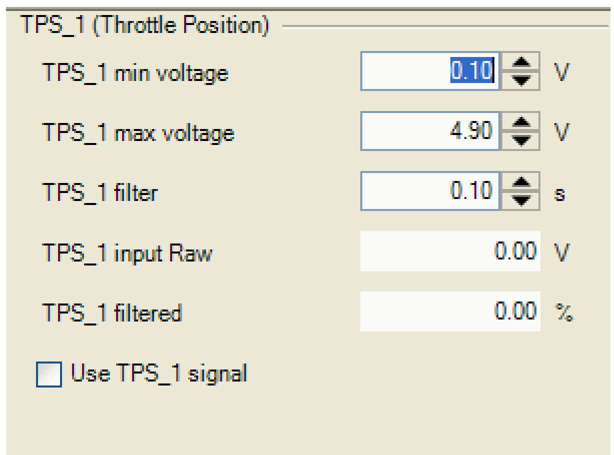


Figure 4-6. HMI Settings for Throttle Position (HMI Screen 4.6)

Actuator Calibration

Depending on the hardware selected, there is an optional procedure to test and configure the mixture actuator for best performance.

Mixture actuator (Throttle) calibration
This procedure is described in Chapter 2 under *Throttle Actuator Calibration*.

Trim actuator calibration
This procedure is described in Chapter 2 under *Trim Valve Calibration*.

Set-up before Starting the Engine

Before starting the engine for the first time with E3 Lean Burn Trim the settings below must be correctly entered by the user.

System Configuration

Configuration of the control needs to be set based on the end user's system.

Torque Limit (MAP Reference) Calibration

For the initial engine start and first calibration, enter the maximum intake manifold pressure in all points of the MAP Reference table.

Use of an Exhaust Gas Analyzer

To ensure that the engine is calibrated in accordance with the manufacturer’s and local requirements, use of a suitable exhaust gas analyzer is recommended to measure the NO_X, O_2 and CO levels in the exhaust gas.

The exhaust gas analyzer should be installed and operated in accordance with the manufacturer’s instructions.

Ignition Timing Settings

If the engine being commissioned includes ignition control by the E3 controller, check that the correct preliminary spark timing settings have been entered in the timing map. See *Ignition Control (IC-920/922 or Smart Coils)* in Chapter 2 for more information.

Speed Control Settings

For complete information on these settings see *Speed Reference* in Chapter 2. Prior to engine start the user should configure the following parameters:

- Idle speed set point
- Rated speed set point (activated after ”Wait at min. speed” time has elapsed)
- Lower and higher limits around the rated speed, to allow synchronization in case of a generator set.
- Raise/Lower Speed Rate.
- Overspeed set point also needs to be configured; this triggers a shutdown of the engine.
- Wait (Warm-up) time at idle – this is the interval between the engine reaching run speed and beginning to ramp to rated speed. For first startup this time can be raised as desired to increase time to check the system while the engine runs at a lower speed.
- When a Droop system is used, the Load Droop percentage and the Droop Mode (Dual Dynamics) selection must be enabled by checking the box beside “Droop Mode (Dual Dynamics)”.

Load Control (Grid mode) Settings

The Load Control (Grid mode) is used in GQCL when the grid breaker is closed and the kW feedback signal is present, and when load control is activated by the user with the HMI. Figure 4-7 shows the HMI user settings for load control. The user should configure the following parameters.

- Minimum and Maximum load
- Raise and Lower rates
- Remote Reference limit and rate

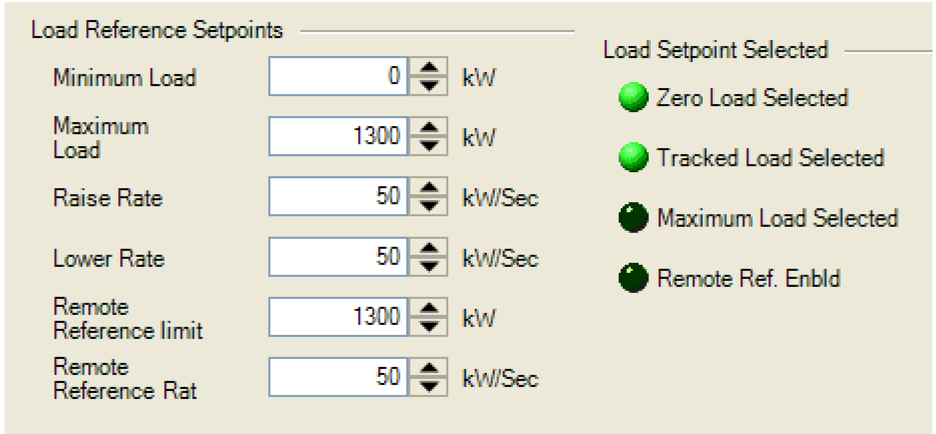


Figure 4-7. HMI Settings for Load Control (HMI Screen 2.5)

LED Indications shown in Figure 4-7 give information about the load set point:

- "Zero Load Selected": Load set point is at minimum
- "Tracked Load Selected": The load set point is equal to the followed/actual load. The load set point tracks the actual load signal when not on grid. When the system is switched on grid the set point can be switched over smoothly from island mode to grid mode.
- "Maximum Load Selected": The maximum load set point is active
- "Remote Ref. Enbld": The Remote load reference is enabled and active:
  - Raise and Lower inputs are both active high (enabled/TRUE)
  - Both the generator and utility breaker are closed (on grid)
  - Remote reference input not failed

Dynamics Settings (Speed Control at First Start-up)

When the system is configured as a speed control appropriate settings need to be entered via the HMI. To start the commissioning it is simpler to select fixed dynamics. Then the gains do not change due to load or speed changes. Figure 4-8 shows the HMI user settings for fixed dynamics.

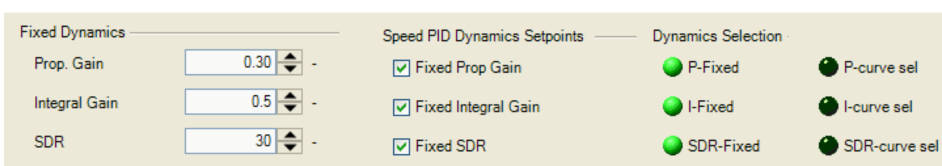


Figure 4-8. HMI Settings for Fixed Dynamics (HMI Screen 2.2)

In a later stage the Dynamics 1 and Dynamics 2 settings can be enabled and adjusted to optimize the speed and load control performance.

Transient Compensation

Transient compensation should be disabled by unchecking the box beside “Use Transient Fuel”.

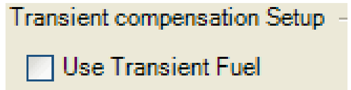


Figure 4-9. HMI Enable/Disable Setting for Transient Compensation

Commissioning IC-920/922 Ignition

When the IC-920/922 ignition is integrated with the E3 system, the ignition controller must be configured before the engine is started the first time.
For the installation and commissioning of the IC-920/922 ignition controller, refer to the user manual, document 26263 and follow the procedures therein.
For J1939 control and communications between the E3 controller and IC-920/922, specific configuration parameters in the ignition controller must be checked and/or adjusted. To do this the IC-900-Series service tool is required. This software can be downloaded from the internet (www.woodward.com) and can also be found on the CD-ROM that is included with the system purchase.

First Firing and Set-up after Starting the Engine

Engine Start

Before starting the engine for the first time:

1. On the Lambda Reference Toolkit screen set all multiplier values in the inlet multiplier table to 1.0.
2. On the Lambda Closed Loop or Gas Quality Closed Loop Toolkit screen, check the “Select Open Loop” box to force the controller into open loop mode.
3. On the Trim Valve Setup Toolkit screen, check the box labeled “Select Manual Trimvalve control”. Enter a value of 40% for the “Manual Trimvalve Setpoint”.
4. Set the carburetor power valve or main adjustment valve to full open. When tuning the carburetor, use the “Manual Trimvalve Setpoint” in place of the carburetor power valve or main adjustment valve.

Record the MAT before the start. Crank the engine with the fuel supply turned off. During cranking, make sure that the E3 receives the speed signal from the magnetic pick-up by monitoring the speed in the HMI. If the speed reading remains at zero during cranking, check the wiring and adjustment (gap) of the MPU(s) (installation instructions can be found under *Engine Speed Sensor (MPU)* in Chapter 3).

When the speed signal is recognized the controller will count down the purge time (see *Purge Time* in Chapter 2), and then energize the gas shut-off valve relay. Before turning on the fuel supply, ensure that the base spark timing is correct, using a timing light while cranking. When this has been done, the fuel supply can be turned on. The engine should start at this time. If the engine does not start, find out if the gas shut-off valve has actually opened by measuring pressure downstream of the valve.

When the engine starts, record the time. This will be used for calibrating the warm-up time.

Failure to Start

If the engine fails to start, check and, if necessary, troubleshoot the following:

- While engine is stopped
  - Alarm and/or shutdown messages that reappear after clicking "Reset Alarms / SD"
- During cranking
  - Alarm and/or shutdown messages that reappear after clicking "Reset Alarms / SD"
  - Speed reading on HMI screen correctly indicates cranking rpm
  - Gas shut-off valve opens after purge time has elapsed
  - Gas is supplied to trim valve
  - Spark events are occurring at correct timing (using timing light)

If no faults exist after performing the steps above and the engine still fails to start, the cause could be that the trim valve open loop position is making the mixture too lean or too rich. Decrease or increase the trim valve position settings (See *Trim valve Settings* in this chapter) and attempt to start the engine. Another option to consider, instead of changing the trim valve position, is adjusting the gas supply pressure to the trim valve.

Tuning Speed Control Dynamics after First Start

After starting the engine, run the engine without load at idle speed (force to idle speed with the discrete input or in the HMI by increasing "Wait at min speed" time).

Next, tune the carburetor for the correct air/fuel ratio at idle using either the Idle Adjustment Screw or the fuel pressure regulator depending on the type of carburetor used.

Now tune the speed control in fixed dynamics mode. This is discussed in under *Dynamics Settings (Speed Control at First Start-up)* in this Chapter. Record the values for the proportional gain, the integral gain, the SDR and the MAP%. Let the speed control ramp to rated speed and retune the P, I, and SDR terms. Record the new values and the MAP%. The two sets of values and the change in MAP% can then be used to configure the proportional gain versus the MAP%.

Dynamics and Open Loop Adjustment at Maximum Load

The following procedure is recommended for running the engine up to maximum load for the first time:

1. Use the fixed dynamics settings as determined above.
2. Increase the engine load in relatively large steps of approximately 25%.
3. If necessary adjust fixed dynamics for stable engine operation. Record the dynamics values for proportional gain, Integral gain, SDR and MAP%, when adjustments are done.
4. Run the engine at full load until temperatures and emissions are stabilized. Note the time elapsed from engine start until cooling water temperature and MAT were stabilized.

5. Tune the carburetor to get the correct air/fuel ratio at full power using the Manual Trimvalve Setpoint instead of the power valve or main adjustment screw.
6. Once the full-power Manual Trimvalve Setpoint has been identified, enter this value in all points of the Trim Valve Open Loop table (see Trim valve Settings in this chapter). Under the Trim Valve Open Loop table set all the Multiplier values in the ECT table to 1.0.
7. On the Trim Valve Setup Toolkit screen, remove the check from the box labeled “Select Manual Trimvalve control”. The control will now be operating in Open Loop mode using the trim valve setpoint from the Trim Valve Open Loop table.
8. Save Values.

Note: the trim valve table will be more finely tuned during the closed loop calibration procedure.

Determine MAT to Inlet Temperature Gain

This function is described in Chapter 2 under *Inlet Temperature*. The temperature gain settings can be copied from an identical engine that has been fully commissioned and is operating satisfactorily, if the MAT sensor is at the same location.
If settings are not available from a similar engine and it is not possible to adjust the MAT or ECT for calibration purposes, the default values can be used.

To calibrate this function, perform the following steps:

1. Increase MAT to an acceptable higher operational value (10 ±5 °C). The objective of this calibration is to find the dependency of the inlet temperature vs a changing MAT. This can be done for example by reducing the water-flow to the charge air cooler, or increasing the temperature of the charge air cooler water.
2. Open the INPUT (MAT vs. IAT) HMI screen and set the temperature gain to zero. In the “Engine Warm-up time” field, enter the time it takes the engine to reach a stabilized coolant temperature as recorded above. Verify that the “Select Inlet Calculation” box is checked.
3. Open the Toolkit screen for Gas Quality Closed Loop (GQCL).
4. Adjust the load to approximately 90% (±10%).
5. Set the “Full Load” power to current power plus 10% and the “Part Load Hi” power to the current power minus 10%.
6. Set the MAP under “Full Load” and “Part Load Hi” to the current MAP value.
7. Set the MAT or IAT under “Full Load” and “Part Load Hi” to the current MAT value.
8. Below the “GQCL – Correction” at the bottom of the screen, set the Temperature Correction value to 0.0 kPa/ºC.
9. On the right side of the screen, be sure that the box labeled “Use MAT or IAT for GQCL” is unchecked.
10. At the top of the screen under “Gas Quality Closed Loop Selections” uncheck the Select Open Loop box. The Gas Quality Closed Loop mode should become active. Allow conditions to stabilize and record the current lambda.
11. Lower MAT to a normal or below normal value. You can expect the lambda to increase slightly.
12. Calculate expected new MAP using the following equation:

$$MAP_{LowerMAT} = MAP_{HigherMAT} \bullet \frac{(MAT_{Lower} + 273)}{(MAT_{Higher} + 273)}$$

13. Allow conditions to stabilize.
14. Increase the “Temperature Correction” on the Gas Quality Closed Loop Toolkit screen until actual MAP is equal to the calculated MAPLowerMAT.
15. Adjust the “Temperature Gain” on the “Input MAT vs IAT” Toolkit screen until actual lambda is equal to the lambda value recorded in step 10.
16. Save this Temperature Gain value by checking the box labeled “Save Values”.
17. This procedure can be repeated at 50% load.

Now Save Values, then make a first settings file download and save to the HMI PC (see the *Help* pull-down menu in Toolkit for instructions, if necessary).

Running in GQCL Mode – Generator Application Only

1. Enable GQCL on the HMI Configuration screen, and force the E3 controller into Open Loop mode.
2. Go to full load in steps and monitor the emissions. Wait until MAT, ECT and the emissions have stabilized before proceeding to the next step.
3. Record the values for MAP, MAT and Load%, and enter these in the applicable fields under “Full Load”. Also record the value of NO_X,
4. Select an intermediate part load operating point (“Part Load Hi” on the HMI screen). Record the values for MAP, MAT and Load%, and enter these in the applicable fields under “Part Load Hi”. Also record the value of NO_X,
5. Select an low part load operating point (“Part Load Med” on the HMI screen) (note that the GQCL algorithm effectiveness is reduced at loads under 40%, so the “Part Load Med” point should be no less than 30% load). Record the values for MAP, MAT and Load%, and enter these in the applicable fields under “Part Load Med”. Also record the value of NO_X,
6. Uncheck “Select Open Loop” and go back to full load.
7. Change IAT by changing MAT or ECT, and wait until the temperatures and emissions have stabilized. At this point, the GQCL logic will compensate for the change in temperature. Make sure that the closed loop correction is smaller than the “Max. CL correction”. If necessary, increase the value of “Max. CL correction”. Also record the value of NO_X,
8. Now tune the parameter “Temperature Correction” until the value of NO_X is the same as the value recorded under item 3.
9. Change the load to “Part Load Hi”, and verify that the value of NO_X is similar to the value recorded under item 4.
10. Change the load to “Part Load Med”, and verify that the value of NO_X is similar to the value recorded under item 5.
11. If the results of steps 9 & 10 are not satisfactory, adjust “Temperature Correction” to get the best overall result.
12. Save Values.

Lambda Reference Table Calibration

After starting the engine and tuning the trim valve open loop table (see *Dynamics and Open Loop adjustment at Maximum Load* and *Trim valve Settings* in this chapter):

1. Load the engine to full power.
2. Using an exhaust gas analyzer or the lambda sensor, check to see that the engine reaches the exhaust emissions or air/fuel ratio expected. To richen the air/fuel ratio, increase the highlighted values on the Trim Valve Open Loop table. To lean the air/fuel ratio decrease the Open Loop table value.
3. Read the actual measured lambda value and enter this value into the Lambda Reference table at the point of the current speed and MAP%.

4. Reduce the engine load approximately 10%. Read the resulting MAP% value and enter in the Lambda Reference table MAP% scale.
5. Repeat steps 4 and 5 at this load level.
6. Continue until the minimum operating load is reached.
7. Save tunable values.
8. If the engine runs at variable speeds, repeat this calibration process reduced speed levels of approximately 10% increments.
9. Enable Lambda Closed Loop by unchecking the box labeled Select Open Loop on the Toolkit screen for Lambda Closed Loop.
10. Check engine emission levels at various load points while in Lambda Closed Loop mode.

Adaptive Learn

After tuning the lambda reference table and the trim valve table this function can be turned on (uncheck the box beside “Disable Adaptive Learn”). If gas quality is changing the position of the trim valve will adjust to compensate. The adaptive learn values for speed/MAP points where compensation has occurred will be saved in the table and will be used to adjust the open loop trim valve position command.
The values in the adaptive learn table are limited by the user specified “Maximum Adaptive Learn limit +/–” The adaptive learn adjustment increments are limited by the user specified “Max. Adaptive Learn Step size”.

The adaptive learn function will operate when the following conditions are simultaneously met:

- The adaptive learn function is not disabled (via the checkbox beside “Disable Adaptive Learn”
- The closed loop correction equals or exceeds the user specified “Max. AFR CL Error to enable Adaptive Learn”
- The user specified “Run delay time” has expired.
- The sensed or calculated ECT equals or exceeds the user specified “ECT Threshold”

Tuning the Speed and Load PID

The stability of a gas engine is directly related to both the speed control and air fuel ratio control. The speed control dynamic settings in the emission tuning were set very slow to enable tuning of the air fuel ratio control. With a properly tuned air fuel ratio control the speed control can then be optimized for the application.

The trending feature in Toolkit should be used. Two approaches are presented the Ziegler-Nichols method and a “Tuning by Feel” method.

For an explanation of the Woodward PID implementation, see PID Control Application Note 83402.

PID Explained

Proportional Gain Action (Prop-gain)

With Proportional Gain, the control output is proportional to the error in measurement or set-point it adjusts the overshoot and undershoot amount.

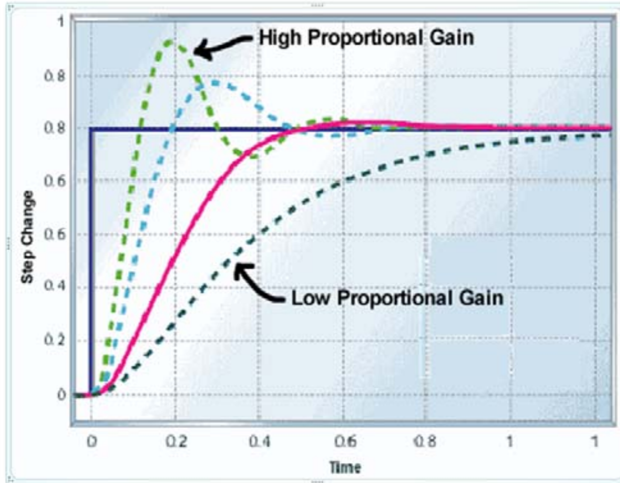


Figure 4-10. Proportional Gain Effect

Integral Action (Integral-gain)

With integral action, the controls output is proportional to the amount of time the speed error is present.

It prevents slow hunting at steady state and controls the time rate at which the speed error returns to zero after a speed or load disturbance.

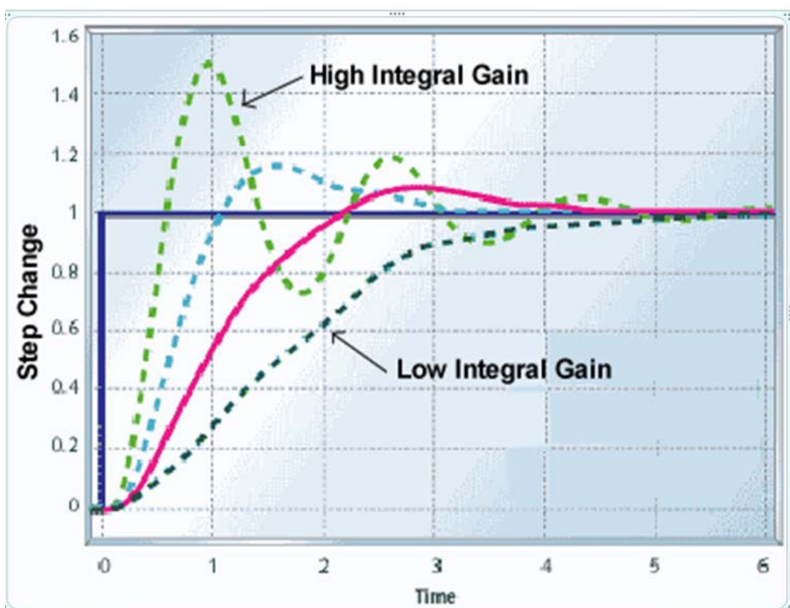


Figure 4-11. Integral Gain Effect

Derivative or Compensation Action (SDR - Speed Derivative Ratio)

With Derivative action, the controls output is proportional to the rate of change, with respect to time, of the error.

Compensation is used to avoid overshoot.

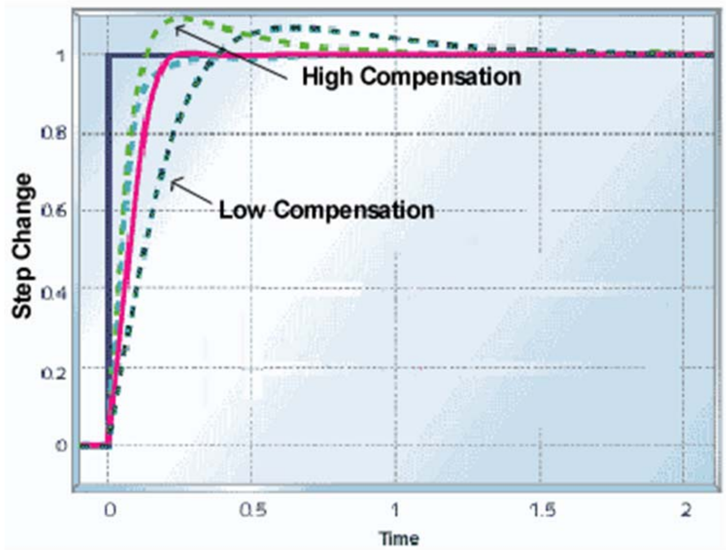


Figure 4-12. SDR (Compensation) Effect

Characteristics of a Correctly Tuned Prime Mover

A correctly tuned prime mover typically usage of P, I, and D terms. Its behavior will show:

1) Stable control at no load.
2) Stable control over all load ranges.
3) Minimum overshoot with no ringing or instability during load transients.

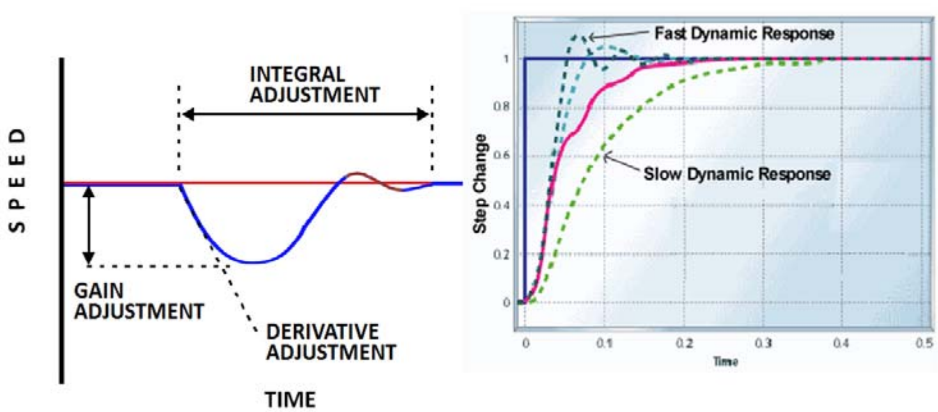
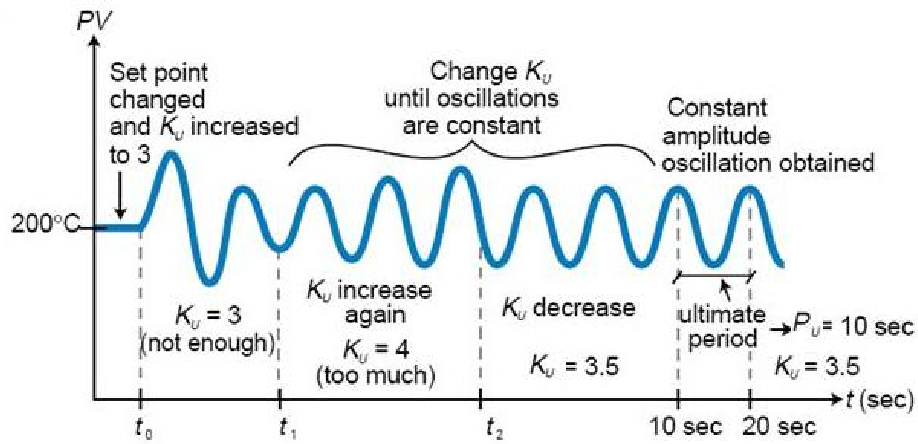


Figure 4-13. PID Together

Ziegler-Nichols

The following Ziegler-Nichols method can be used to achieve PID gain values that are close:

1. To start tuning the speed/load control, the process must be in a stable steady state condition. If operation is not stable, the Proportional gain should be reduced from 0.4 until the process stabilizes.
2. **Increase Speed Derivative Ratio (SDR) to 100.**
3. **Reduce integral gain to 0.01.**
4. **Increase proportional gain in 150% steps until the system just starts to oscillate.**
   - *The optimum gain for this step is when the system just starts to oscillate and maintains a self-sustaining oscillation that does not increase or decrease in magnitude.*



5. **Record the proportional ultimate gain (Ku) and ultimate oscillation period (Pu) in seconds**

6. **Set the dynamics as follows:**
   - **For PI control G=P(I/s + 1) set:**
     1. – Proportional gain = 0.45*Ku
     2. – Integral gain = 1.2/Pu
     3. – Derivative ratio = 100
   - **For PID control G=P(I/s + 1 + Ds) set:**
     1. – Proportional gain = 0.60*Ku
     2. – Integral gain = 2/Pu
     3. – Deriv ratio = 8/Pu for feedback dominant
        1. Use this first
     4. – Deriv ratio = Pu/8 for input dominant
2. Perform load step tests to verify settings adjusting as necessary for optimum response.

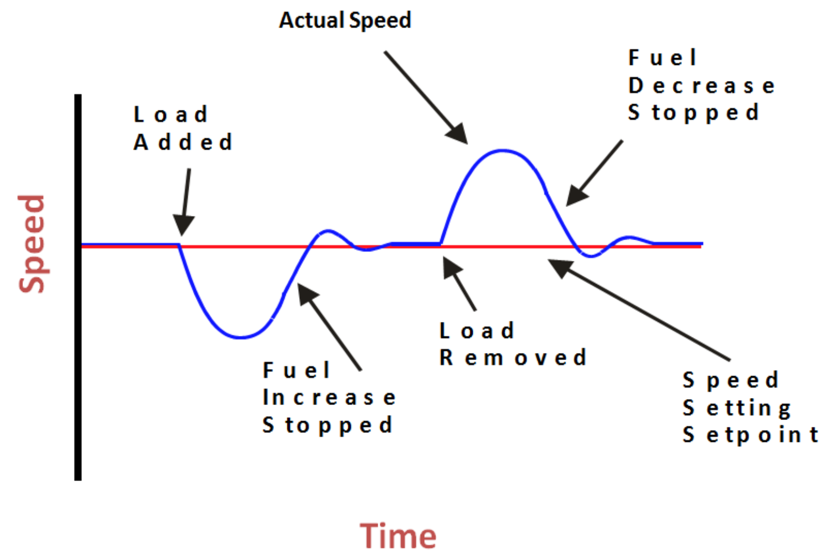


Figure 4-14. Textbook PID Response

Ziegler Nichols Overview

Advantages
- Easy experiment; only need to change the P controller
- Includes dynamics of whole process, which gives a more accurate picture of how the system is behaving

Disadvantages
- Experiment can be time consuming
- Can venture into unstable regions while testing the P controller, which could cause the system to become out of control

Tuning by Feel Method

This method involves systematic trial and error.

Proportional

Set Proportional to a low value 0.4

Turn off Reset (0.01)
Set Derivative to minimum effect. Turn Derivative, in Woodward controls "S_D_R", to high number, SDR = 100.
Create an upset of the throttle using “Bump Enable” of 1 to 10% depending on how much swing process can tolerate.

Allow time for at least 90% of the change to take place

If no cycle occurs, increase Proportional by doubling gain and changing load to create a disturbance.
Repeat until first small cycle is seen, adjust Proportional in smaller increments until 1/4 decay ratio is obtained.
Be sure to allow time for 90% of change to take place before changing settings.

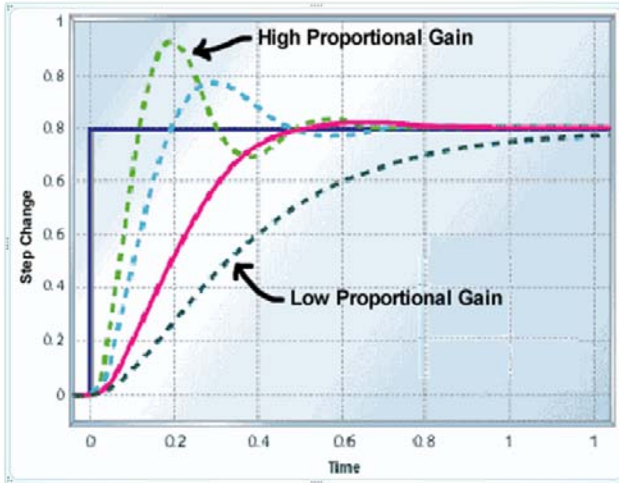


Figure 4-15. Proportional Gain Effect

Integral

Turn Integral gain on to very slow action (0.1).
Bump the engine load to recreate upset.
If no effect increase Integral in 150% increments until first effect is seen (similar to Proportional step).
After first effect is seen, add Integral in small increments until required response is obtained.

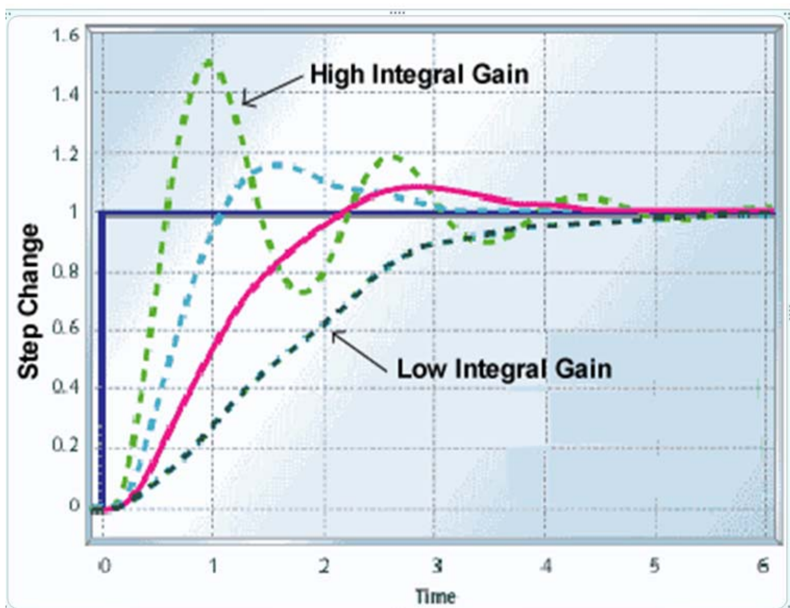


Figure 4-16. Integral Gain Effect

Speed Derivative Ratio (SDR)

Set SDR to 50
Use "Bump Enable" to recreate upset.

Decrease SDR by 50% until desired response is obtained.

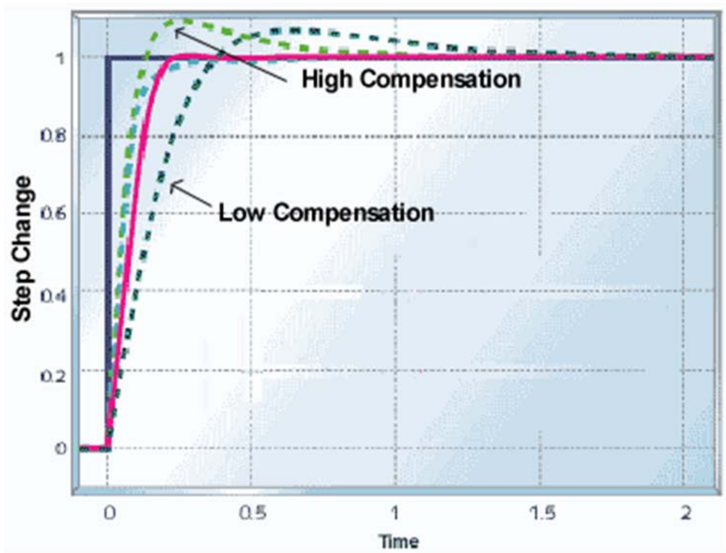


Figure 4-17. SDR (Compensation) Effect

Further Refinement

Restart procedure finding final value for each term.

Check both upset conditions and load change conditions after all above steps are completed.

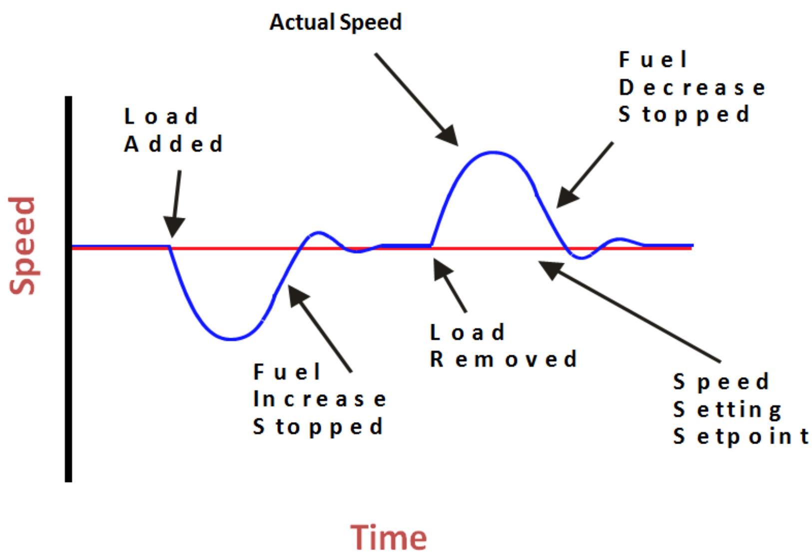


Figure 4-18. Textbook PID Response

Speed Dependent Dynamics

Used on constant speed applications like generators.

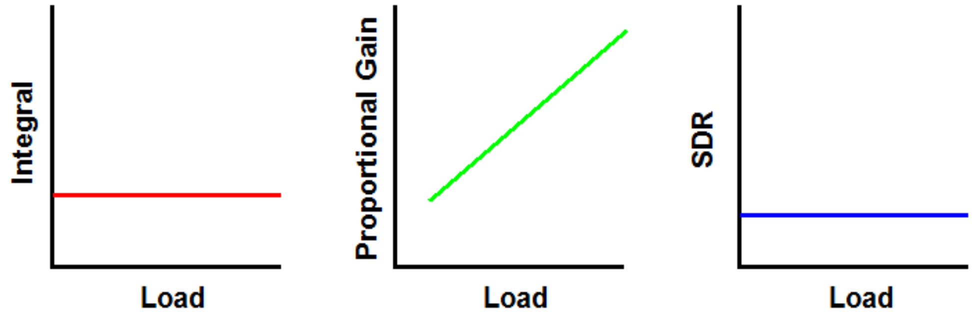


Figure 4-19. Speed Dependent Dynamics

Misfire Detection Calibration

The default settings have been refined based on numerous applications however it is recommended that end users very the default settings.

Disabling ignition on individual cylinders for the purpose of calibrating misfire detection should be done on the primary side of the coils. Disconnecting the sparkplug cables when the engine is running is NOT recommended. The coil(s) can be damaged because of the high voltage that arises if the spark cannot jump! This also poses a risk of shock to personnel near the engine.

⚠WARNING	**HIGH VOLTAGE—Modern ignition systems can produce very high voltages which can be very dangerous.**

Alarm Override at Starting and Synchronization

To avoid misfire alarms during starting and synchronization misfire detection is only active above the user specified "Minimum Load for Misfire Detection".

Calibration of the Misfire Detection

Misfire Detection should be calibrated to always recognize a misfire condition, but should not produce false alarms. In order to achieve this balance, the following procedure should be followed.

Misfire alarm table

The filtered speed derivative signal changes in response to engine load. When the engine is operating normally (no misfire, normal A/F ratio etc.) a baseline curve of filtered speed derivative versus engine load is defined. When the speed derivative signal is at or below this curve, this is interpreted as no misfire. During misfire calibration it must be determined how far the derivative signal may go above this baseline before triggering an alarm. The derivative level vs. load (Calc Fuel %) table for triggering a misfire alarm on the ToolKit misfire screen allows the user to adjust different alarm levels for different levels of Calc Fuel %.

The alarm is disabled below an adjustable load level. This to avoid spurious alarms, as the derivative signal to noise ratio is poor at low load.

Before starting the calibration it is recommended to override the misfire alarms. The ability to adjust load on the engine between 0 and 100% is required for this procedure.

Calibration of Misfire

The Misfire output will be load dependent. It is necessary to compare the misfire output at various load levels during continuous single cylinder misfire conditions for EVERY cylinder against a reference "no misfire" running condition at the same load level.

Abbreviated commissioning

1. Note the MISFIRE output level when no misfire is occurring at each relevant load point
   a. Set the Alarm level to 4x that level
   b. Set the Shutdown level to 10x of that level
   c. Enable “Use Misfire to Freeze Ccor”

Full commissioning

1. Note the MISFIRE output level when no misfire is occurring at each relevant load point
2. Then cause a continuous single cylinder misfire on EACH cylinder one by one.
3. Note the MISFIRE output level during each cylinder misfire.
4. The lowest MISFIRE value of any cylinder misfire should be at least 4 times higher than the reference (no misfire) value at the same load level.
5. Set your misfire alarm condition based on a level below the lowest MISFIRE value at the given load point but well above the reference value. To avoid false alarms due to transient conditions, the alarm condition should be required to be present for some minimum time before taking action.
6. Set the Shutdown level to 10x the background level or to 80% of complete misfire level for the lowest cylinder.

Misfire Explained

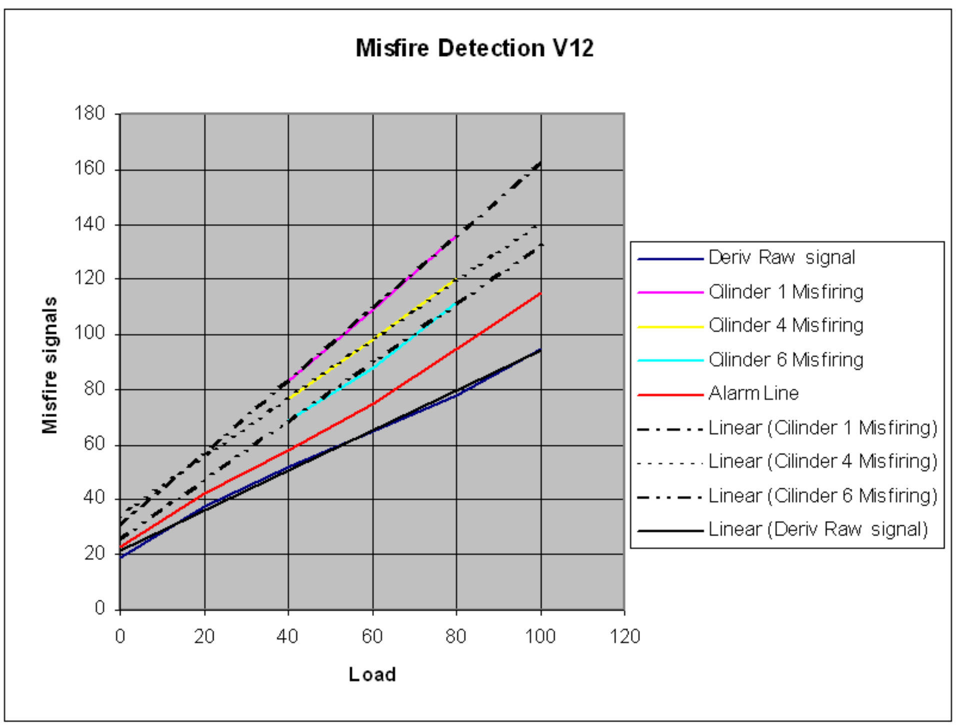


Figure 4-20. Misfire Detection Curves

Misfire Filter Tau
The speed derivative signal is filtered to tune misfire detection sensitivity to "noise". The default value of 0.2 s should be a good starting point. When the filter time constant is too high, the responsiveness of the misfire detection will be reduced. The filter time (Tau) applies to a second order filter.

Minimum Load for Misfire Detection
The engine should be cycled through several starts and stops to check if false misfires are detected during starting and stopping. The idle, running, and synchronization modes should also be checked. The minimum load (Calc Fuel %) for misfire detection should be adjusted during these checks if misfire is indicated at lower loads but is not really occurring.

Misfire Samples
The recommended setting for the number of samples parameter ("Samples = Number of Cyls") is the number of cylinders of the engine. If desired, the setting can be fine tuned by trial and error. The maximum value is 16.

Alarm Delay
The alarm delay should be tuned to avoid false misfire detection during transients.

Control Response to Misfire Detection
The response of the E3 controller to misfire detection is user configurable. There will always be an alarm. At the user's option, a shutdown on misfire detection can be selected by checking the box beside "Misfire SD Alarm Active". If shutdown is not selected, and the box beside "Use Misfire to Freeze Ccor" is checked, Ccor will be frozen at its last value, upon detection of misfire. If neither box is checked, the alarm will be given but there will be no control response.

Transient Fuelling Calibration

Figure 4-21 shows the HMI settings for transient fueling compensation. Begin by monitoring NO_X levels with an analyzer and performing different load steps to observe the dynamic response of the engine. With the transient logic disabled (uncheck the box beside "Use Transient Fuel"), record the dMAP/dt for different load steps. Choose a suitable threshold for the transient bias to become active. With transient logic enabled, the transient dynamic behavior of the engine can be optimized by adjusting the dMAP/dt thresholds, 'Map filter" and K-Factor. For more information, see *Transient Fuel Compensation Logic* in Chapter 2.

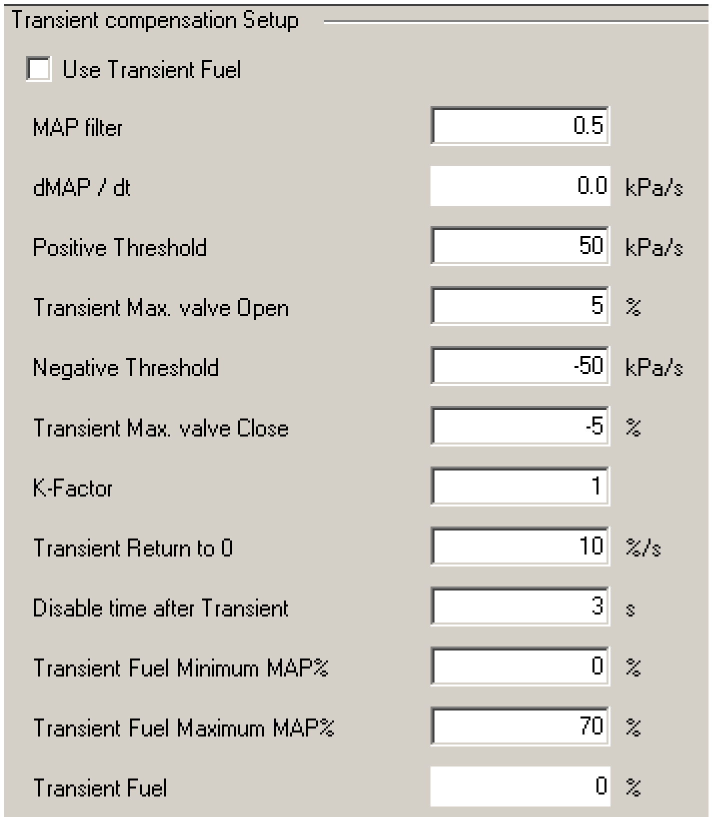


Figure 4-21. Transient Logic Basic Settings (HMI Screen 1.6)

Chapter 5. Diagnostics

Introduction

To facilitate troubleshooting problems in the system and to protect the engine, all the critical parameters are monitored via diagnostics logic.

There are three possible reactions of the E3 to a diagnostic event:

- Alarm with no derate
- Alarm with derate
- Shutdown

Below is a listing of all the alarms and shutdowns in numerical order. The alarms (not shutdowns) can be overridden by the user if desired via the HMI, if communication with the control is established at or above the required password level. It is also possible to configure the control response to the different diagnostic events.

All the alarms and shutdowns are latching. This means that on the occurrence of a diagnostic event, the controller will record this information and keep the alarm/shutdown active, until it receives a reset command and the cause for the event has been removed.

Resets for the alarms can be commanded with the engine running; shutdowns can only be reset after the engine is stopped.

Table 5-1 is a full listing of alarms and shutdowns. The HMI alarm and shutdown screens are shown in Figures 5-1 through 5-7.

Table 5-1. E3 System Alarms

Modbus Boolean Read	MSG_	ID_	FMI_ID_	SPN_ID_
1:0001	"AL01 LOSS OF POWER"	111	18	168
1:0002	"SD01 LOSS OF POWER"	112	31	168
1:0003	"AL02 BANK 1 TOO LEAN"	113	15	1119
1:0004	"AL03 BANK 1 TOO RICH"	114	16	1119
1:0005	"AL04 BANK 2 TOO LEAN"	115	15	516099
1:0006	"AL05 BANK 2 TOO RICH"	116	16	516099
1:0007	"AL20 MAP_1 SENSOR VOLTAGE LOW"	117	4	106
1:0008	"SD20 MAP_1 SENSOR VOLTAGE LOW"	118	14	106
1:0009	"AL25 BARO OUT OF RANGE"	119	13	108
1:0010	"AL30 MAP_1 SENSOR VOLTAGE HI"	120	3	106
1:0011	"SD30 MAP_1 SENSOR VOLTAGE HI"	121	31	106
1:0012	"AL40 MAP_2 SENSOR VOLTAGE LOW"	122	4	3562
1:0013	"SD40 MAP_2 SENSOR VOLTAGE LOW"	123	14	3562
1:0014	"AL50 MAP_2 SENSOR VOLTAGE HI"	124	3	3562
1:0015	"SD50 MAP_2 SENSOR VOLTAGE HI"	125	31	3562
1:0016	"AL60 MAP DIFFERENCE OUT OF RANGE"	126	16	516107
1:0017	"SD61 MAP DIFFERENCE OUT OF RANGE"	127	0	516107
1:0018	"AL71 CAM SENSOR FLT"	128	2	723
1:0019	"SD72 CRANK SENSOR FLT"	129	2	190
1:0020	"AL75 MAX CAM TIMING ERROR EXCEEDED"	130	16	723
1:0021	"SD75 MAX CAM TIMING ERROR EXCEEDED"	131	0	723
1:0022	"AL76 CAM/CRK SYNC ERROR"	132	7	723

1:0023	"SD80 ENGINE OVERSPEED"	133	0	190
1:0024	"SD81 ENGINE STALLED"	134	1	190
1:0025	"SD85 KEY OFF"	135	31	1865
1:0026	"AL90 LOAD SENSOR VOLTAGE LO"	136	4	2452
1:0027	"SD90 LOAD SENSOR VOLTAGE LO"	137	14	2452
1:0028	"AL100 LOAD SENSOR VOLTAGE HI"	138	3	2452
1:0029	"SD100 LOAD SENSOR VOLTAGE HI"	139	31	2452
1:0030	"AL111 UEGO 1 SENSE CELL FAILURE"	140	12	724
1:0031	"SD111 UEGO 1 SENSE CELL FAILURE"	141	7	724
1:0032	"AL112 UEGO 1 HEATER VOLTAGE LO"	142	4	724
1:0033	"SD112 UEGO 1 HEATER VOLTAGE LO"	143	14	724
1:0034	"AL113 UEGO 1 SENSOR NOT READY"	144	13	724
1:0035	"SD113 UEGO 1 SENSOR NOT READY"	145	11	724
1:0036	"AL114 UEGO 1 SENSOR FAULT"	146	8	724
1:0037	"SD114 UEGO 1 SENSOR FAULT"	147	2	724
1:0038	"AL115 UEGO 2 SENSE CELL FAILURE"	148	12	516099
1:0039	"SD115 UEGO 2 SENSE CELL FAILURE"	149	7	516099
1:0040	"AL116 UEGO 2 HEATER VOLTAGE LO"	150	4	516099
1:0041	"SD116 UEGO 2 HEATER VOLTAGE LO"	151	14	516099
1:0042	"AL117 UEGO 2 SENSOR NOT READY"	152	13	516099
1:0043	"SD117 UEGO 2 SENSOR NOT READY"	153	11	516099
1:0044	"AL118 UEGO 2 SENSOR FAULT"	154	8	516099
1:0045	"SD118 UEGO 2 SENSOR FAULT"	155	2	516099
1:0046	"AL121 UEGO 1 HEATER VOLTAGE HI"	156	3	724
1:0047	"SD121 UEGO 1 HEATER VOLTAGE HI"	157	31	724
1:0048	"AL122 UEGO 2 HEATER VOLTAGE HI"	158	3	516099
1:0049	"SD122 UEGO 2 HEATER VOLTAGE HI"	159	31	516099
1:0050	"AL123 LAMBDA DIFF OUT OF RANGE AL"	160	16	516106
1:0051	"SD124 LAMBDA DIFF OUT OF RANGE SD"	161	0	516106
1:0052	"AL130 MAT_1 SENSOR VOLTAGE LO"	162	4	105
1:0053	"SD130 MAT_1 SENSOR VOLTAGE LO"	163	14	105
1:0054	"AL140 MAT_1 SENSOR VOLTAGE HI"	164	3	105
1:0055	"SD140 MAT_1 SENSOR VOLTAGE HI"	165	31	105
1:0056	"AL141 MAT_1 TEMPERATURE HI"	166	15	105
1:0057	"SD142 MAT_1 TEMPERATURE HI"	167	0	105
1:0058	"AL143 MAT_1 TEMPERATURE HI DERATE"	168	16	105
1:0059	"AL144 MAT_2 SENSOR VOLTAGE LO"	169	4	1131
1:0060	"SD144 MAT_2 SENSOR VOLTAGE LO"	170	14	1131
1:0061	"AL145 MAT_2 SENSOR VOLTAGE HI"	171	3	1131
1:0062	"SD145 MAT_2 SENSOR VOLTAGE HI"	172	31	1131
1:0063	"AL146 MAT_2 TEMPERATURE HI"	173	15	1131
1:0064	"SD147 MAT_2 TEMPERATURE HIHI"	174	0	1131
1:0065	"AL148 MAT_2 TEMPERATURE HI DERATE"	175	16	1131
1:0066	"AL150 ECT SENSOR VOLTAGE LO"	176	4	110
1:0067	"SD150 ECT SENSOR VOLTAGE LO"	177	14	110
1:0068	"AL151 LUBE OIL PRESSURE VOLTAGE LO"	178	4	100
1:0069	"SD151 LUBE OIL PRESSURE VOLTAGE LO"	179	14	100
1:0070	"AL152 LUBE OIL PRESSURE VOLTAGE HI"	180	3	100
1:0071	"SD152 LUBE OIL PRESSURE VOLTAGE HI"	181	31	100
1:0072	"AL160 ECT SENSOR VOLTAGE HI"	182	3	110
1:0073	"SD160 ECT SENSOR VOLTAGE HI"	183	31	110
1:0074	"AL161 ECT TEMPERATURE HI"	184	15	110
1:0075	"SD162 ECT TEMPERATURE HI"	185	0	110
1:0076	"AL163 ECT TEMPERATURE HI DERATE"	186	16	110
1:0077	"AL190 REMOTE INPUT VOLTAGE LO"	187	4	3938
1:0078	"SD190 REMOTE INPUT VOLTAGE LO"	188	14	3938
1:0079	"AL200 REMOTE INPUT VOLTAGE HI"	189	3	3938
1:0080	"SD200 REMOTE INPUT VOLTAGE HI"	190	31	3938
1:0081	"AL210 TPS1 VOLTAGE LO"	191	4	51
1:0082	"AL211 TPS2 VOLTAGE LO"	192	4	516111

1:0083	"AL212 TPS3 VOLTAGE LO"	193	4	516112
1:0084	"AL213 TPS4 VOLTAGE LO"	194	4	516113
1:0085	"SD210 TPS1 VOLTAGE LO"	195	14	51
1:0086	"SD211 TPS2 VOLTAGE LO"	196	14	516111
1:0087	"SD212 TPS3 VOLTAGE LO"	197	14	516112
1:0088	"SD213 TPS4 VOLTAGE LO"	198	14	516113
1:0089	"AL220 TPS1 VOLTAGE HI"	199	3	51
1:0090	"AL221 TPS2 VOLTAGE HI"	200	3	516111
1:0091	"AL222 TPS3 VOLTAGE HI"	201	3	516112
1:0092	"AL223 TPS4 VOLTAGE HI"	202	3	516113
1:0093	"SD220 TPS1 VOLTAGE HI"	203	31	51
1:0094	"SD221 TPS2 VOLTAGE HI"	204	31	516111
1:0095	"SD222 TPS3 VOLTAGE HI"	205	31	516112
1:0096	"SD223 TPS4 VOLTAGE HI"	206	31	516113
1:0097	"AL230 5 VOLT SUPPLY XDRP_A LO"	207	4	1079
1:0098	"AL240 5 VOLT SUPPLY XDRP_A HI"	208	3	1079
1:0099	"AL250 5 VOLT SUPPLY XDRP_B LO"	209	4	1080
1:0100	"AL260 5 VOLT SUPPLY XDRP_B HI"	210	3	1080
1:0101	"AL261 14 VOLT SUPPLY LO"	211	4	1543
1:0102	"AL262 14 VOLT SUPPLY HI"	212	3	1543
1:0103	"AL270 LAMBDA1 CL CORR > MAX LIM"	213	16	1696
1:0104	"AL275 LAMBDA2 CL CORR > MAX LIM"	214	16	516100
1:0105	"AL280 LAMBDA1 CL CORR < MIN LIM"	215	18	1696
1:0106	"AL285 LAMBDA2 CL CORR < MIN LIM"	216	18	516100
1:0107	"AL290 GQCL > MAX LIMIT"	217	0	1116
1:0108	"AL300 GQCL < MIN LIMIT"	218	1	1116
1:0109	"SD310 CAN1 CONTROLLER ERROR STATUS"	219	2	639
1:0110	"AL311 CAN2 CONTROLLER ERROR STATUS"	220	2	1231
1:0111	"SD320 CAN1 CONTROLLER BUS OFF STATUS"	221	31	639
1:0112	"AL321 CAN2 CONTROLLER BUS OFF STATUS"	222	31	1231
1:0113	"SD330 MAIN SUPPLY VOLTAGE LO"	223	4	168
1:0114	"SD340 MAIN SUPPLY VOLTAGE HI"	224	3	168
1:0115	"AL350 SPEED BIAS VOLTAGE LO"	225	17	3938
1:0116	"AL360 SPEED BIAS VOLTAGE HI"	226	15	3938
1:0117	"AL370 MISFIRE DETECTED"	227	16	1322
1:0118	"SD380 MISFIRE DETECTED"	228	0	1322
1:0119	"AL381 THROTTLE POSITION DIFF"	229	16	516108
1:0120	"SD382 THROTTLE POSITION DIFF"	230	0	516108
1:0121	"AL383 TRIM POSITION DIFF"	231	16	516109
1:0122	"SD384 TRIM POSITION DIFF"	232	0	516109
1:0123	"AL440 ENGINE OVERLOAD (MAX LOAD LIM)"	233	0	92
1:0124	"AL441 ENGINE LOW POWER"	234	1	3464
1:0125	"SD442 UNCONTROLLED OVERPOWER BANK 1"	235	16	3464
1:0126	"AL443 ENGINE LOW POWER BANK 2"	236	1	3465
1:0127	"SD444 UNCONTROLLED OVERPOWER BANK 2"	237	16	3465
1:0128	"SD480 EXTERNAL SHUTDOWN 1 ACTIVE"	238	31	701
1:0129	"SD481 EXTERNAL SHUTDOWN 2 ACTIVE"	239	31	702
1:0130	"SD482 EXTERNAL SHUTDOWN 3 ACTIVE"	240	31	703
1:0131	"SD483 EXTERNAL SHUTDOWN 4 ACTIVE"	241	31	704
1:0132	"AL485 LUBE OIL PRESSURE LO"	242	17	100
1:0133	"SD486 LUBE OIL PRESSURE LO"	243	1	100
1:0134	"AL487 LUBE OIL PRESSURE LO DERATE"	244	18	100
1:0135	"AL490 LUBE OIL LEVEL LO"	245	17	98
1:0136	"SD491 LUBE OIL LEVEL LO"	246	1	98
1:0137	"AL492 LUBE OIL LEVEL LO DERATE"	247	18	98
1:0138	"AL495 COOLANT LEVEL LO"	248	17	111
1:0139	"SD496 COOLANT LEVEL LO"	249	1	111
1:0140	"AL497 COOLANT LEVEL LO DERATE"	250	18	111
1:0141	"AL700 RATEGROUP SLIP"	251	12	629
1:0142	"AL701 PCMHD HIGH TEMPERATURE"	252	0	1136

1:0143	"AL702 PCMHD EEPROM PRIMARY FLT"	253	12	628
1:0144	"AL703 PCMHD EEPROM SECONDARY FLT"	254	7	628
1:0145	"SD800 EASYGEN CAN WATCHDOG TIMEOUT"	255	9	516110
1:0146	"AL801 EASYGEN STOP COMMAND"	256	14	516110
1:0147	"SD920 IC920 CAN WATCHDOG TIMEOUT"	257	9	1292
1:0148	"AL1000 IC920 ERR MISS RING GEAR SIG"	258	8	723
1:0149	"AL1001 IC920 ERR MISS RST SIG"	259	2	637
1:0150	"AL1002 IC920 ERR MISS CAM SIG"	260	2	726
1:0151	"AL1003 IC920 ERR NUM OF GEAR TEETH"	261	13	723
1:0152	"AL1004 IC920 UKN ENGINE APPL CODE"	262	11	1292
1:0153	"AL1005 IC920 OVERSPEED SHUTDOWN"	263	11	1614
1:0154	"AL1006 IC920 EEPROM CHECKSUM ERROR"	264	31	1292
1:0155	"AL1007 IC920 GLOB TIM OUT OF RANGE"	265	19	1436
1:0156	"AL1008 IC920 UKN GLOB TIM OR ENERGY"	266	19	1433
1:0157	"AL1009 IC920 IND TIMING OUT OF RANGE"	267	20	1433
1:0158	"AL1010 IC920 OPEN PRIM RATE EXCEED"	268	0	1292
1:0159	"AL1011 IC920 WAIT FOR 0 SPEED"	269	8	1292
1:0160	"AL1012 IC920 OPEN PRIMARY CHANNEL 1"	270	13	1268
1:0161	"AL1013 IC920 OPEN PRIMARY CHANNEL 2"	271	13	1269
1:0162	"AL1014 IC920 OPEN PRIMARY CHANNEL 3"	272	13	1270
1:0163	"AL1015 IC920 OPEN PRIMARY CHANNEL 4"	273	13	1271
1:0164	"AL1016 IC920 OPEN PRIMARY CHANNEL 5"	274	13	1272
1:0165	"AL1017 IC920 OPEN PRIMARY CHANNEL 6"	275	13	1273
1:0166	"AL1018 IC920 OPEN PRIMARY CHANNEL 7"	276	13	1274
1:0167	"AL1019 IC920 OPEN PRIMARY CHANNEL 8"	277	13	1275
1:0168	"AL1020 IC920 OPEN PRIMARY CHANNEL 9"	278	13	1276
1:0169	"AL1021 IC920 OPEN PRIMARY CHANNEL 10"	279	13	1277
1:0170	"AL1022 IC920 OPEN PRIMARY CHANNEL 11"	280	13	1278
1:0171	"AL1023 IC920 OPEN PRIMARY CHANNEL 12"	281	13	1279
1:0172	"AL1024 IC920 OPEN PRIMARY CHANNEL 13"	282	13	1280
1:0173	"AL1025 IC920 OPEN PRIMARY CHANNEL 14"	283	13	1281
1:0174	"AL1026 IC920 OPEN PRIMARY CHANNEL 15"	284	13	1282
1:0175	"AL1027 IC920 OPEN PRIMARY CHANNEL 16"	285	13	1283
1:0176	"AL1028 IC920 OPEN PRIMARY CHANNEL 17"	286	13	1284
1:0177	"AL1029 IC920 OPEN PRIMARY CHANNEL 18"	287	13	1285
1:0178	"AL1030 IC920 OPEN PRIMARY CHANNEL 19"	288	13	1286
1:0179	"AL1031 IC920 OPEN PRIMARY CHANNEL 20"	289	13	1287
1:0180	"AL1032 IC920 WARN MISS RING GEAR SIG"	290	14	723
1:0181	"AL1033 IC920 WARN MISS RESET SIG"	291	8	637
1:0182	"AL1034 IC920 WARN MISS CAM SIG"	292	8	726
1:0183	"AL1035 IC920 ODD ENGY LVL OUT OF RNG"	293	16	1292
1:0184	"AL1036 IC920 EVEN ENGY LVL OUT OF RNG"	294	20	1292
1:0185	"AL1037 IC920 SCR FAULT ODD"	295	2	1292
1:0186	"AL1038 IC920 SCR FAULT EVEN"	296	2	1293
1:0187	"SD1300 THROTTLE1 GENERAL SHUTDOWN"	297	0	3464
1:0188	"AL1301 THROTTLE1 GENERAL ALARM"	298	15	3464
1:0189	"AL1305 THROTTLE1 POSITION ERROR"	299	13	3464
1:0190	"SD1305 THROTTLE1 POSITION ERROR"	300	2	3464
1:0191	"SD1308 THROTTLE1 WATCHDOG CAN TIMEOUT"	301	7	3464
1:0192	"SD1310 THROTTLE2 GENERAL SHUTDOWN"	302	0	3465
1:0193	"AL1311 THROTTLE2 GENERAL ALARM"	303	15	3465
1:0194	"AL1315 THROTTLE2 POSITION ERROR"	304	13	3465
1:0195	"SD1315 THROTTLE2 POSITION ERROR"	305	2	3465
1:0196	"SD1318 THROTTLE2 WATCHDOG CAN TIMEOUT"	306	7	3465
1:0197	"SD1320 FTV 1 GENERAL SHUTDOWN"	307	0	633
1:0198	"AL1321 FTV 1 GENERAL ALARM"	308	15	633
1:0199	"AL1325 FTV 1 POSITION ERROR"	309	13	633
1:0200	"SD1325 FTV 1 POSITION ERROR"	310	2	633
1:0201	"SD1328 FTV 1 WATCHDOG CAN TIMEOUT"	311	7	633
1:0202	"SD1330 FTV 2 GENERAL SHUTDOWN"	312	0	1244

1:0203	"AL1331 FTV 2 GENERAL ALARM"	313	15	1244
1:0204	"AL1335 FTV 2 POSITION ERROR"	314	13	1244
1:0205	"SD1335 FTV 2 POSITION ERROR"	315	2	1244
1:0206	"SD1338 FTV 2 WATCHDOG CAN TIMEOUT"	316	7	1244
1:0207	"AL1401 CYLINDER 1 OPEN CIRCUIT"	317	5	1268
1:0208	"SD1401 CYLINDER 1 OPEN CIRCUIT"	318	31	1268
1:0209	"AL1402 CYLINDER 2 OPEN CIRCUIT"	319	5	1269
1:0210	"SD1402 CYLINDER 2 OPEN CIRCUIT"	320	31	1269
1:0211	"AL1403 CYLINDER 3 OPEN CIRCUIT"	321	5	1270
1:0212	"SD1403 CYLINDER 3 OPEN CIRCUIT"	322	31	1270
1:0213	"AL1404 CYLINDER 4 OPEN CIRCUIT"	323	5	1271
1:0214	"SD1404 CYLINDER 4 OPEN CIRCUIT"	324	31	1271
1:0215	"AL1405 CYLINDER 5 OPEN CIRCUIT"	325	5	1272
1:0216	"SD1405 CYLINDER 5 OPEN CIRCUIT"	326	31	1272
1:0217	"AL1406 CYLINDER 6 OPEN CIRCUIT"	327	5	1273
1:0218	"SD1406 CYLINDER 6 OPEN CIRCUIT"	328	31	1273
1:0219	"AL1407 CYLINDER 7 OPEN CIRCUIT"	329	5	1274
1:0220	"SD1407 CYLINDER 7 OPEN CIRCUIT"	330	31	1274
1:0221	"AL1408 CYLINDER 8 OPEN CIRCUIT"	331	5	1275
1:0222	"SD1408 CYLINDER 8 OPEN CIRCUIT"	332	31	1275
1:0223	"AL1411 CYLINDER 1 SHORT CIRCUIT"	333	6	1268
1:0224	"SD1411 CYLINDER 1 SHORT CIRCUIT"	334	14	1268
1:0225	"AL1412 CYLINDER 2 SHORT CIRCUIT"	335	6	1269
1:0226	"SD1412 CYLINDER 2 SHORT CIRCUIT"	336	14	1269
1:0227	"AL1413 CYLINDER 3 SHORT CIRCUIT"	337	6	1270
1:0228	"SD1413 CYLINDER 3 SHORT CIRCUIT"	338	14	1270
1:0229	"AL1414 CYLINDER 4 SHORT CIRCUIT"	339	6	1271
1:0230	"SD1414 CYLINDER 4 SHORT CIRCUIT"	340	14	1271
1:0231	"AL1415 CYLINDER 5 SHORT CIRCUIT"	341	6	1272
1:0232	"SD1415 CYLINDER 5 SHORT CIRCUIT"	342	14	1272
1:0233	"AL1416 CYLINDER 6 SHORT CIRCUIT"	343	6	1273
1:0234	"SD1416 CYLINDER 6 SHORT CIRCUIT"	344	14	1273
1:0235	"AL1417 CYLINDER 7 SHORT CIRCUIT"	345	6	1274
1:0236	"SD1417 CYLINDER 7 SHORT CIRCUIT"	346	14	1274
1:0237	"AL1418 CYLINDER 8 SHORT CIRCUIT"	347	6	1275
1:0238	"SD1418 CYLINDER 8 SHORT CIRCUIT"	348	14	1275
1:0239	"SD1430 ALL COILS OPEN CIRCUIT FLT"	349	5	1292
1:0240	"SD1440 ALL COILS SHORT CIRCUIT FLT"	350	6	1292

E3 System Alarms – Detailed Description

All faults are latching and require an operator to manually reset them.

All faults designated “SD” are shutdown faults. All faults designated “AL” are alarms that will annunciate but not shut the unit down.

AL01 LOSS OF POWER
SD01 LOSS OF POWER

This fault is set upon power-up; it informs the user that power has been lost.

AL02 BANK 1 TOO LEAN
AL03 BANK 1 TOO RICH
AL04 BANK 2 TOO LEAN
AL05 BANK 2 TOO RICH

The measured Lambda is compared to the:
- Desired Lambda + "Max Lambda difference" for Too Rich
- Desired Lambda - "Min Lambda difference" for Too Lean

The individual alarms are activated when all of the following conditions are simultaneously met:
- AFR mode selected and active (not GQCL mode)
- No UEGO sensor faults
- Engine speed is be higher than the user specified "Min. Speed"
- |Actual Lambda – Measured lambda| > user specified "Max Lambda difference"
- Box beside "Enable Lambda difference alarm" is checked
- The alarm delay timer has expired

AL MAP_1 sensor voltage Low
SD20 MAP_1 sensor voltage Low
AL MAP_1 sensor voltage Hi
SD30 MAP_1 sensor voltage Hi

The individual alarms are activated when the following conditions are simultaneously met:
- The MAP_1 sensor voltage is above the user specified "MAP_1 max voltage" or below the user specified "MAP_1 min voltage"
- The alarm delay timer has expired

AL25 (BARO out of Range)

This alarm is activated when the following conditions are simultaneously met:
- No AL20 or AL30, i.e. MAP_1 sensor voltage is within normal operating range
- Sensed barometric pressure outside user defined range.
- The alarm delay timer has expired

AL40 MAP_2 sensor voltage Low
SD40 MAP_2 sensor voltage Low
AL50 MAP_2 sensor voltage Hi
SD50 MAP_2 sensor voltage Hi

The individual alarms are activated when the following conditions are simultaneously met:
- The MAP_2 sensor voltage is above the user specified "MAP_2 max voltage" or below the user specified "MAP_2 min voltage"
- The alarm delay timer has expired

AL60 MAP DIFFERENCE OUT OF RANGE
This protection alarm activates when the measured MAP_1 and MAP_2 difference is exceeded by the threshold for the delay time.

SD61 MAP DIFFERENCE OUT OF RANGE
This protection Shutdown activates when the measured MAP_1 and MAP_2 difference is exceeded by the threshold for the delay time

AL71 CAM SENSOR FLT

This alarm is activated when the following conditions are simultaneously met:

- Pattern 2 is selected
- Engine is rotating at a sufficient speed for CAM signal to be detected
- Crank signal is detected
- Speed Control mode has been selected
- The signal received on the cam input does not match the selected pattern.

SD72 CRANK SENSOR FLT

This alarm is activated when the following conditions are simultaneously met:

- Pattern 3 is selected
- Speed Control mode has been selected
- Engine rotation is being detected on the CAM sensor input
- No signal is received on the SPD1 input

AL75 MAX CAM TIMING ERROR EXCEEDED
SD75 MAX CAM TIMING ERROR EXCEEDED

This alarm is activated when the following conditions are simultaneously met:

- AL75 has been enabled by the user
- Pattern 2 is selected
- Speed Control mode has been selected
- Engine is running (measured speed is above user defined “Run Speed”)
- Sensed position of the cam pulse with respect to crank tooth #1 in crank angle degrees exceeds the user defined threshold.

AL76 CAM/CRK SYNC ERROR

This alarm is activated when the following conditions are simultaneously met:

- Pattern 2 is selected
- Speed Control mode has been selected
- Engine is running (measured speed is above user defined “Run Speed”)
- The E3 controller does not detect the expected cam pulse after 2 engine rotations, based the on the user defined number of teeth on the flywheel.

SD80 ENGINE OVERSPEED

This alarm is activated when the following conditions are simultaneously met:

- Sensed speed is above the user defined overspeed set point.
- The alarm delay timer has expired.

SD81 ENGINE STALLED

This alarm is activated when the following conditions are simultaneously met:

- Engine was running (i.e. sensed speed was above user defined “Run Speed”) and was stopped abnormally
- No STOP command has been received
- The alarm delay timer has expired.

SD85 KEY OFF

This alarm is activated when the following conditions are simultaneously met:
- Key switch input voltage drops below 10 Vdc
- The shutdown delay timer has expired.

AL90 LOAD SENSOR VOLTAGE LO
SD90 LOAD SENSOR VOLTAGE LO
AL100 LOAD SENSOR VOLTAGE HI
SD100 LOAD SENSOR VOLTAGE HI

The load sensor input is required when the system is configured as a GQCL generator application (it is optional when the system is configured for lambda closed loop operation).

The individual alarms are activated when the following conditions are simultaneously met:
- The load sensor input voltage is above the user specified "Load min voltage" or below the user specified "Load min voltage".
- The alarm delay timer has expired

When one of the individual alarms is active in GQCL mode, the GQCL logic will switch to open loop control.

AL111 UEGO 1 SENSE CELL FAILURE
SD111 UEGO 1 SENSE CELL FAILURE

This alarm is activated when the following conditions are simultaneously met:
- The engine is running (i.e. sensed speed is above user defined "Run Speed")
- Lambda closed loop mode is selected
- The measured UEGO sense cell voltage is above the user specified "UEGO Sense cell max. Voltage" or below the user specified "UEGO Sense cell min. Voltage".
- Sensed UEGO sensor tip temperature is within the normal operating range as defined in the software
- The alarm delay timer has expired

When this alarm is active the lambda closed loop logic will switch to open loop.

AL112 UEGO 1 HEATER VOLTAGE LO
SD112 UEGO 1 HEATER VOLTAGE LO

The individual alarms are activated when the following conditions are simultaneously met:
- The engine is running (i.e. sensed speed is above user defined "Run Speed")
- Lambda closed loop mode is selected
- The sensed UEGO heater voltage is above the user specified "Lo Heater voltage" or below the user specified "Hi Heater voltage".
- The alarm delay timer has expired

When this alarm is active the lambda closed loop logic will switch to open loop.

AL113 UEGO 1 SENSOR NOT READY
SD113 UEGO 1 SENSOR NOT READY

This alarm is activated when the following conditions are simultaneously met:

- The engine is running (i.e. sensed speed is above user defined “Run Speed”)
- Lambda closed loop mode is selected
- Sensed UEGO sensor temperature is lower than the normal operating temperature, for longer than the setting “Run Time before Not Ready”.
- The alarm delay timer has expired

When this alarm is active the lambda closed loop logic will switch to open loop.

AL114 UEGO 1 SENSOR FAULT
SD114 UEGO 1 SENSOR FAULT

This alarm is activated when the following conditions are simultaneously met:

- The engine is running (i.e. sensed speed is above user defined “Run Speed”)
- Lambda closed loop mode is selected
- A fault with the UEGO sensor, wiring or UEGO control hardware internal to the E3 controller, other than AL111-113 or AL121, is detected
- The alarm delay timer has expired
- This fault and the other UEGO sensor faults AL111-113 and AL121 are not mutually exclusive

When this alarm is active the lambda closed loop logic will switch to open loop. There are no user adjustable parameters for this alarm.

AL115 UEGO 2 SENSE CELL FAILURE
SD115 UEGO 2 SENSE CELL FAILURE

This alarm is activated when the following conditions are simultaneously met:

- The engine is running (i.e. sensed speed is above user defined “Run Speed”)
- Lambda closed loop mode is selected
- The measured UEGO sense cell voltage is above the user specified “UEGO Sense cell max. Voltage” or below the user specified “UEGO Sense cell min. Voltage”.
- Sensed UEGO sensor tip temperature is within the normal operating range as defined in the software
- The alarm delay timer has expired

When this alarm is active the lambda closed loop logic will switch to open loop.

AL116 UEGO 2 HEATER VOLTAGE LO
SD116 UEGO 2 HEATER VOLTAGE LO

The individual alarms are activated when the following conditions are simultaneously met:

- The engine is running (i.e. sensed speed is above user defined “Run Speed”)
- Lambda closed loop mode is selected
- The sensed UEGO heater voltage is above the user specified “Lo Heater voltage”
- The alarm delay timer has expired

When this alarm is active the lambda closed loop logic will switch to open loop.

AL117 UEGO 2 SENSOR NOT READY
SD117 UEGO 2 SENSOR NOT READY

This alarm is activated when the following conditions are simultaneously met:

- The engine is running (i.e. sensed speed is above user defined “Run Speed”)
- Lambda closed loop mode is selected
- Sensed UEGO sensor temperature is lower than the normal operating temperature, for longer than the setting “Run Time before Not Ready”.
- The alarm delay timer has expired

When this alarm is active the lambda closed loop logic will switch to open loop.

AL118 UEGO 2 SENSOR FAULT
SD118 UEGO 2 SENSOR FAULT

This alarm is activated when the following conditions are simultaneously met:

- The engine is running (i.e. sensed speed is above user defined “Run Speed”)
- Lambda closed loop mode is selected
- A fault with the UEGO sensor, wiring or UEGO control hardware internal to the E3 controller, other than AL111-113 or AL121, is detected
- The alarm delay timer has expired
- This fault and the other UEGO sensor faults AL111-113 and AL121 are not mutually exclusive

When this alarm is active the lambda closed loop logic will switch to open loop. There are no user adjustable parameters for this alarm.

AL121 UEGO 1 HEATER VOLTAGE HI
SD121 UEGO 1 HEATER VOLTAGE HI

The individual alarms are activated when the following conditions are simultaneously met:

- The engine is running (i.e. sensed speed is above user defined “Run Speed”)
- Lambda closed loop mode is selected
- The sensed UEGO heater voltage is above the user specified “Hi Heater voltage”
- The alarm delay timer has expired

When this alarm is active the lambda closed loop logic will switch to open loop.

AL122 UEGO 2 HEATER VOLTAGE HI
SD122 UEGO 2 HEATER VOLTAGE HI

The individual alarms are activated when the following conditions are simultaneously met:

- The engine is running (i.e. sensed speed is above user defined “Run Speed”)
- Lambda closed loop mode is selected
- The sensed UEGO heater voltage is above the user specified “Hi Heater voltage”
- The alarm delay timer has expired

When this alarm is active the lambda closed loop logic will switch to open loop.

AL123 LAMBDA DIFF OUT OF RANGE AL
SD124 LAMBDA DIFF OUT OF RANGE SD

The individual alarms are activated when the following conditions are simultaneously met:

- “Stereo Engine” is selected
- Lambda closed loop mode is selected
- Lambda 1 measured and Lambda 2 measured exceed the fault threshold

When this alarm is active the lambda closed loop logic will switch to open loop.

AL130 MAT_1 SENSOR VOLTAGE LO
SD130 MAT_1 SENSOR VOLTAGE LO
AL140 MAT_1 SENSOR VOLTAGE HI
SD140 MAT_1 SENSOR VOLTAGE HI

The individual alarms are activated when the following conditions are simultaneously met:

- The sensed MAT sensor voltage is above the user specified “MAT_1 max voltage” or below the user specified “MAT_1 min voltage”.
- The alarm delay timer has expired

When this alarm is active, the user specified “MAT @ sensor failure” is used as the value for MAT_1.

When the system is configured as a GQCL generator application, the user may select whether to maintain or disable GQCL operation when this alarm is active. This is done using the checkbox beside “MAT 1 sensor failure disables GQCL?” on the GQCL HMI screen.

AL141 MAT_1 TEMPERATURE HI
SD142 MAT_1 TEMPERATURE HIHI
AL143 MAT_1 TEMPERATURE HI DERATE

The MAT engine protection functions are enabled when the following conditions are simultaneously met:

- MAT Alarm/Derate Logic is enabled (by checking the box beside “Use MAT Alarm/Derate Logic”)
- Sensed MAT sensor voltage is in range (AL130 – MAT_1 Sensor voltage Lo) and AL140 – MAT_1 Sensor voltage Hi are not active)

MAT engine protection is activated when sensed inlet manifold temperature is in range and exceeds user specified thresholds for user specified durations. There are three levels of protection, using three thresholds and two timers. The first level is an alarm only (AL141 – MAT Temperature Hi Alarm), which is activated when the sensed MAT exceeds the user specified “MAT Alarm Threshold” for the user specified “MAT Alarm Delay”. The second level is a progressive (i.e. time based) engine derate (AL143 – MAT Temperature Derate active), which derates the final engine power by the user specified “MAT Derate Stepsize” every user specified “MAT Derate Looptime” seconds that the sensed MAT exceeds the user specified “MAT Derate Threshold”. When the sensed MAT no longer exceeds “MAT Alarm Threshold”, the power derate is removed by the user specified “MAT Derate Clear Stepsize” every “MAT Derate Looptime” seconds.

The third level of protection is engine shutdown (AL142 – MAT Temperature Hi Shutdown). When the power derate becomes and remains equal to or less than the user specified “MAT Derate Shutdown Threshold” for the user specified “MAT Shutdown Delay” seconds, shutdown will occur.

It is possible to configure these functions to have an alarm only, alarm with derate only, alarm with derate and shutdown, shutdown preceded by alarm, or shutdown only, by appropriately adjusting the settings.

The default configuration is for immediate shutdown only.

Note that the power derate function is intended for mechanical drive applications and is not applicable to generator applications.

AL144 MAT_2 SENSOR VOLTAGE LO
SD144 MAT_2 SENSOR VOLTAGE LO
AL145 MAT_2 SENSOR VOLTAGE HI
SD145 MAT_2 SENSOR VOLTAGE HI

The individual alarms are activated when the following conditions are simultaneously met:

- The sensed MAT sensor voltage is above the user specified “MAT_2 max voltage” or below the user specified “MAT_2 min voltage”.
- The alarm delay timer has expired

When this alarm is active, the user specified “MAT @ sensor failure” is used as the value for MAT_2.

When the system is configured as a GQCL generator application, the user may select whether to maintain or disable GQCL operation when this alarm is active. This is done using the checkbox beside “MAT 1 sensor failure disables GQCL?” on the GQCL HMI screen.

AL146 MAT_2 TEMPERATURE HI
SD147 MAT_2 TEMPERATURE HI
AL148 MAT_2 TEMPERATURE HI DERATE

The MAT engine protection functions are enabled when the following conditions are simultaneously met:

- MAT Alarm/Derate Logic is enabled (by checking the box beside “Use MAT Alarm/Derate Logic”)
- Sensed MAT sensor voltage is in range
-

MAT engine protection is activated when sensed inlet manifold temperature is in range and exceeds user specified thresholds for user specified durations. There are three levels of protection, using three thresholds and two timers. The first level is an alarm only AL146 MAT_2 TEMPERATURE HI, which is activated when the sensed MAT exceeds the user specified “MAT Alarm Threshold” for the user specified “MAT Alarm Delay”. The second level is a progressive (i.e. time based) engine derate AL148 MAT_2 TEMPERATURE HI DERATE, which derates the final engine power by the user specified “MAT Derate Stepsize” every user specified “MAT Derate Looptime” seconds that the sensed MAT exceeds the user specified “MAT Derate Threshold”. When the sensed MAT no longer exceeds “MAT Alarm Threshold”, the power derate is removed by the user specified “MAT Derate Clear Stepsize” every “MAT Derate Looptime” seconds.

The third level of protection is engine shutdown SD147 MAT_2 TEMPERATURE HI. When the power derate becomes and remains equal to or less than the user specified "MAT Derate Shutdown Threshold" for the user specified "MAT Shutdown Delay" seconds, shutdown will occur.

It is possible to configure these functions to have an alarm only, alarm with derate only, alarm with derate and shutdown, shutdown preceded by alarm, or shutdown only, by appropriately adjusting the settings.

The default configuration is for immediate shutdown only.

Note that the power derate function is intended for mechanical drive applications and is not applicable to generator applications.

AL150 ECT SENSOR VOLTAGE LO
SD150 ECT SENSOR VOLTAGE LO
AL160 ECT SENSOR VOLTAGE HI
SD160 ECT SENSOR VOLTAGE HI

The individual alarms are activated when the following conditions are simultaneously met:

- The input is enabled (by checking the box beside "Use Engine Coolant Temperature sensor")
- The sensed ECT sensor voltage is above the user specified "ECT max voltage" or below the user specified "ECT min voltage".
- The alarm delay timer has expired

When AL150 or AL160 is active, the user specified "ECT @ sensor failure" is used as the value for ECT.

AL151 LUBE OIL PRESSURE VOLTAGE LO
SD151 LUBE OIL PRESSURE VOLTAGE LO
AL152 LUBE OIL PRESSURE VOLTAGE HI
SD152 LUBE OIL PRESSURE VOLTAGE HI

The individual alarms are activated when the following conditions are simultaneously met:

- The input is enabled (by checking the box beside "Use Lube Oil Pressure sensor")
- The sensed lube oil pressure sensor voltage is above the user specified "Lube Oil Pressure max. Voltage" or below the user specified "Lube Oil Pressure min. Voltage".
- The alarm delay timer has expired

When AL151 or AL152 is active, the E3 controller will use the last valid reading taken when the sensor voltage was in range.

AL161 ECT TEMPERATURE HI
SD162 ECT TEMPERATURE HI
AL163 ECT TEMPERATURE HI DERATE

The ECT engine protection functions are enabled when the following conditions are simultaneously met:

- ECT Alarm/Derate Logic is enabled (by checking the box beside "Use ECT Alarm/Derate Logic")
- Sensed ECT sensor voltage is in range (AL150 – ECT_2 Sensor voltage Lo) and AL160 – ECT_1 Sensor voltage Hi are not active)

The ECT engine protection functions are activated when sensed inlet manifold temperature is in range and exceeds user specified thresholds for user specified durations.

There are three levels of protection, using three thresholds and two timers. The first level is an alarm only (AL161 – ECT Temperature Hi Alarm), which is activated when the sensed ECT exceeds the user specified “ECT Alarm Threshold” for the user specified “ECT Alarm Delay”. The second level is a progressive (i.e. time based) engine derate (AL163 – ECT Temperature Derate active), which derates the final engine power by the user specified “ECT Derate Stepsize” every user specified “ECT Derate Looptime” seconds that the sensed ECT exceeds the user specified “ECT Derate Threshold”. When the sensed ECT no longer exceeds “ECT Alarm Threshold”, the power derate is removed by the user specified “ECT Derate Clear Stepsize” every “ECT Derate Looptime” seconds.

The third level of protection is engine shutdown (AL162 – ECT Temperature Hi Shutdown). When the power derate becomes and remains equal to or less than the user specified “ECT Derate Shutdown Threshold” for the user specified “ECT Shutdown Delay” seconds, shutdown will occur.

It is possible to configure these functions to have an alarm only, alarm with derate only, alarm with derate and shutdown, shutdown preceded by alarm, or shutdown only, by appropriately adjusting the settings.

The default configuration is for immediate shutdown only.

Note that the power derate function is intended for mechanical drive applications and is not applicable to generator applications.

AL190 REMOTE INPUT VOLTAGE LO
SD190 REMOTE INPUT VOLTAGE LO
AL200 REMOTE INPUT VOLTAGE HI
SD200 REMOTE INPUT VOLTAGE HI

The individual alarms are activated when the following conditions are simultaneously met:

- Generator mode is selected
- Remote reference input is enabled by checking the box beside “Use Spd/Ld reference input”
- The remote reference voltage is above the user specified “Speed/load ref max voltage” or below the user specified “Speed/load ref min voltage”
- The alarm delay timer has expired

When AL190 or AL200 is active, the E3 controller will use the last valid reading taken when the sensor voltage was in range.

AL210 TPS1 VOLTAGE LO
AL211 TPS2 VOLTAGE LO
AL212 TPS3 VOLTAGE LO
AL213 TPS4 VOLTAGE LO
SD210 TPS1 VOLTAGE LO
SD211 TPS2 VOLTAGE LO
SD212 TPS3 VOLTAGE LO
SD213 TPS4 VOLTAGE LO
AL220 TPS1 VOLTAGE HI

AL221 TPS2 VOLTAGE HI
AL222 TPS3 VOLTAGE HI
AL223 TPS4 VOLTAGE HI
SD220 TPS1 VOLTAGE HI
SD221 TPS2 VOLTAGE HI
SD222 TPS3 VOLTAGE HI
SD223 TPS4 VOLTAGE HI

The individual alarms are applicable when a mixture throttle with throttle position feedback is used in the system
The individual alarms are activated when the following conditions are simultaneously met:

- TPS_X input is enabled using “Use TPS_X signal”
- The TPS_X voltage is above the user specified “TPS_X max voltage” or below the user specified “TPS_X min voltage”
- The alarm delay timer has expired

When AL210 thru AL223 is active, the TPS will be set to zero.

AL230 5 VOLT SUPPLY XDRP_A LO
AL240 5 VOLT SUPPLY XDRP_A HI

The individual alarms provide detection and warning of high or low voltage on the transducer power supply XDRP_A from the E3 controller.
The individual alarms are activated when the following conditions are simultaneously met:

- The sensed output voltage is above the max. limit (5.1 V) or below the min. limit (4.9 V).
- Engine speed is higher than 150 rpm and lower than the user specified “Run Speed”)
- The alarm delay timer has expired

The user cannot change the alarm thresholds.

AL250 5 VOLT SUPPLY XDRP_B LO
AL260 5 VOLT SUPPLY XDRP_B HI

The individual alarms provide detection and warning of high or low voltage on the transducer power supply XDRP_B from the E3 controller.

The individual alarms are activated when the following conditions are simultaneously met:

- The sensed output voltage is above the max. limit (5.1 V) or below the min. limit (4.9 V).
- Engine speed is higher than 150 rpm and lower than the user specified “Run Speed”)
- The alarm delay timer has expired

The user cannot change the alarm thresholds.

AL261 14 VOLT SUPPLY LO
AL262 14 VOLT SUPPLY HI

The individual alarms provide detection and warning of high or low voltage on the internal 14 V power supply of the ECU (PCM128-HD).

The individual alarms are activated when the following conditions are simultaneously met:

- The input voltage is higher than the maximum threshold of 18 V or lower than the minimum threshold 10 V
- The engine speed is higher than the user specified "Run Speed"
- The alarm delay timer has expired

The user cannot change the alarm thresholds.

AL270 LAMBDA1 CL CORR > MAX LIM
AL275 LAMBDA2 CL CORR > MAX LIM
AL280 LAMBDA1 CL CORR < MIN LIM
AL285 LAMBDA2 CL CORR < MIN LIM

The individual alarms are activated when the following conditions are simultaneously met:

- The E3 controller is configured to run in Lambda Closed Loop mode
- The engine speed is higher than the user defined "Run Speed"
- Lambda Closed Loop mode is active, i.e. no UEGO sensor faults
- The closed loop correction equals the user defined "Max. CL Correction +/–"
- The alarm delay timer has expired

AL290 GQCL > MAX LIMIT
AL300 GQCL < MIN LIMIT

The individual alarms are activated when the following conditions are simultaneously met:

- The E3 controller is configured to run in GQCL mode
- The engine speed is higher than the user defined "Run Speed"
- GQCL mode is active, i.e. no load, MAP, MAT (optional) sensor faults
- The closed loop correction has reached the user defined "Max. CL Correction +/–"
- The alarm delay timer has expired

SD310 CAN1 CONTROLLER ERROR STATUS

This alarm provides detection and warning of an internal error in the CAN1 processor (J1939 communications) on board the E3 controller.

This alarm is activated when the following conditions are simultaneously met:

- The E3 system is configured with a J1939 device (IC-920/-922, L-Series, F-Series, FireFly) on the engine J1939 link
- The internal diagnostics logic detects a problem with the CAN1 processor
- The alarm delay timer has expired

AL310 will not be set if the engine J1939 bus is not used.

AL311 CAN2 CONTROLLER ERROR STATUS

This alarm provides detection and warning of an internal error of the CAN2 processor (J1939 communications) on board the E3 controller.

This alarm is activated when the following conditions are simultaneously met:

- The E3 system is configured with a J1939 device (easYgen, upper level system) on the external J1939 link
- The internal diagnostics logic detects a problem with the CAN2 processor
- The alarm delay timer has expired

AL311 will not be set if the external J1939 bus is not used.

SD320 CAN1 CONTROLLER BUS OFF STATUS

This alarm provides detection and warning of a bus off condition of the CAN1 processor (J1939 communications) on board the E3 controller. This alarm emulates the J1939 standard red status led functionality.

This alarm is activated when the following conditions are simultaneously met:

- The E3 system is configured with a J1939 device (IC-920/-922, L-Series, F-Series, FireFly) on the engine J1939 link
- No J1939 messages are detected on the bus
- The alarm delay timer has expired

SD320 will not be set if the engine J1939 bus is not used.

AL321 CAN2 CONTROLLER BUS OFF STATUS

This alarm provides detection and warning of a bus off condition of the CAN2 processor (J1939 communications) on board the E3 controller. This alarm emulates the J1939 standard red status led functionality.

This alarm is activated when the following conditions are simultaneously met:

- The E3 system is configured with a J1939 device (easYgen-3000, upper level system) on the engine J1939 link
- No J1939 messages are detected on the bus
- The alarm delay timer has expired

AL321 will not be set if the external J1939 bus is not used.

SD330 MAIN SUPPLY VOLTAGE LO
SD340 MAIN SUPPLY VOLTAGE HI

The individual alarms provide detection and warning of high or low supply voltage to the E3 controller.

The individual alarms are active when the following conditions are simultaneously met:

- The engine speed is higher than the user defined “Run Speed”
- The input voltage is higher than the maximum threshold or lower than the minimum threshold
- The alarm delay timer has expired

The user cannot change the alarm thresholds.

AL350 SPEED BIAS VOLTAGE LO
AL360 SPEED BIAS VOLTAGE HI

The individual alarms are activated when the following conditions are simultaneously met:

- Speed control is enabled in the system
- Speed bias signal is enabled in the system
- The speed bias voltage is above the user specified “Speed Bias max voltage” or below the user specified “Speed Bias min voltage”
- The alarm delay timer has expired

When AL350 or AL360 is active, the speed bias will be set to zero.

AL370 MISFIRE DETECTED
SD380 MISFIRE DETECTED

The individual alarms are activated when the following conditions are simultaneously met:

- The engine speed is higher than the user defined “Run Speed” (AL 370 & AL380)
- The engine load (MAP%) is greater than the user defined “Minimum MAP% for Misfire Detection” (AL 370 & AL380)
- The measured misfire level exceeds the user defined table “Derivative Alarm level” (AL 370 & AL380)
- The alarm delay timer has expired (AL 370 & AL380)
- AL380 is enabled by checking the box next to “Shutdown Engine when Misfire detected” (AL380 only)

AL381 THROTTLE POSITION DIFF
SD382 THROTTLE POSITION DIFF

The individual alarms are activated when the following conditions are simultaneously met:

- “Stereo Engine” is selected
- Speed Control is enabled
- Throttle Position 1 and Throttle Position 2 exceed the fault threshold

AL383 TRIM POSITION DIFF
SD384 TRIM POSITION DIFF

The individual alarms are activated when the following conditions are simultaneously met:

- “Stereo Engine” is selected
- Fuel Trim Position 1 and Fuel Trim Position 2 exceed the fault threshold

AL440 ENGINE OVERLOAD (MAX LOAD LIM)

This alarm provides detection and warning of an engine overload condition. This logic uses measured MAP% for engine load – see *Fuel Limit (Map Reference)* in Chapter 2 for more information.

This alarm is activated when the following conditions are simultaneously met:

- The engine speed is higher than the user defined “Run Speed”
- Parameter “MAP Reference control Active (Torque Limited)” is active
- Parameter “Speed control Active” is not active
- The alarm delay timer has expired

AL441 ENGINE LOW POWER

This alarm provides detection and warning of low engine power.

This alarm is activated when the following conditions are simultaneously met:
- The engine speed is higher than the user defined "Run Speed"
- Parameter "Speed control Active" is active
- Parameter "MAP Reference control Active (Torque Limited)" is not active
- Mixture throttle PID output is greater than 90%
- The difference between load/speed reference and measured speed/load is greater than 2%
- The alarm delay timer has expired

SD442 UNCONTROLLED OVERPOWER BANK 1

The aim of this function is to provide a safe engine shutdown in the event overpower occurs that cannot be arrested via throttle command signal. The primary inputs for this function are the mixture throttle TPS and status signals. If these signals are not present or are invalid this function will use secondary data.

The overpower logic provides for engine shutdown when MAP exceeds the reference value plus an offset due to a malfunctioning throttle that is indicated by a TPS error, when a valid TPS signal is present (note that if the throttle is functioning correctly – i.e. the TPS signal is valid and is following the commanded position – the system should be able to bring the power (MAP) under control by closing the throttle, so no action is taken by this function until/unless throttle is already being commanded to 0). But if TPS alarm/shutdown logic is disabled (e.g. because TPS signal not implemented) or if there is any TPS malfunction (Voltage Hi/Lo or TPS error) then shutdown will occur as soon as throttle position command goes to zero, which will happen quickly as the torque limiting function attempts to limit MAP.

Note that this function will be pre-empted by a TPS triggered shutdown if any of the configurable TPS alarm/shutdowns are configured for shutdown and are active. There are no user adjustable settings for this function.
This individual alarm provides detection, warning and protection from an uncontrolled overpower condition.

This alarm is activated when the following conditions are simultaneously met:
- The engine speed is higher than the user defined "Run Speed"
- Sensed MAP is equal to or greater than MAP Reference + 30 kPa AND:
    - TPS_1 sensor input is enabled in the system, sensed TPS_1 voltage is in range, AL210 (TPS Sensor voltage Low) and AL220 (TPS Sensor voltage Hi) are not active) AND:
      The calculated value of TPS_1 filtered is greater than or less than the Mixture Throttle Demand Pos. (from PID) by more than 10%
      OR:
    - Mixture Throttle Demand Pos. (from PID) = 0
- The alarm delay timer has expired

AL443 ENGINE LOW POWER BANK 2

This alarm provides detection and warning of low engine power.

This alarm is activated when the following conditions are simultaneously met:
- The engine speed is higher than the user defined "Run Speed"
- Parameter "Speed control Active" is active
- Parameter "MAP Reference control Active (Torque Limited)" is not active
- Mixture Throttle2 PID output is greater than 90%
- The difference between load/speed reference and measured speed/load is greater than 2%
- The alarm delay timer has expired

SD444 UNCONTROLLED OVERPOWER BANK 2

The aim of this function is to provide a safe engine shutdown in the event overpower occurs that cannot be arrested via throttle command signal. The primary inputs for this function are the mixture throttle TPS and status signals. If these signals are not present or are invalid this function will use secondary data.

The overpower logic provides for engine shutdown when MAP exceeds the reference value plus an offset due to a malfunctioning throttle that is indicated by a TPS error, when a valid TPS signal is present (note that if the throttle is functioning correctly – i.e. the TPS signal is valid and is following the commanded position – the system should be able to bring the power (MAP) under control by closing the throttle, so no action is taken by this function until/unless throttle is already being commanded to 0). But if TPS alarm/shutdown logic is disabled (e.g. because TPS signal not implemented) or if there is any TPS malfunction (Voltage Hi/Lo or TPS error) then shutdown will occur as soon as throttle position command goes to zero, which will happen quickly as the torque limiting function attempts to limit MAP.

Note that this function will be pre-empted by a TPS triggered shutdown if any of the configurable TPS alarm/shutdowns are configured for shutdown and are active. There are no user adjustable settings for this function.
This individual alarm provides detection, warning and protection from an uncontrolled overpower condition.

This alarm is activated when the following conditions are simultaneously met:
- The engine speed is higher than the user defined "Run Speed"
- Sensed MAP is equal to or greater than MAP Reference + 30 kPa AND:
    - TPS_2 sensor input is enabled in the system, sensed TPS_2 voltage is in range, AL211 TPS2 Sensor Voltage Lo and AL221 TPS2 Sensor Voltage Hi) are not active) AND:
      The calculated value of TPS_1 filtered is greater than or less than the Mixture Throttle Demand Pos. (from PID) by more than 10%
      OR:
    - Mixture Throttle2 Demand Pos. (from PID) = 0
- The alarm delay timer has expired

AL463 (F-Series 1 CAN watchdog timeout) – Shutdown only

This alarm provides detection and warning of an F-Series throttle J1939 timeout.

This alarm is activated when the following conditions are simultaneously met:

- F-Series with J1939 capability is used as mixture throttle in the system
- F-Series with J1939 capability is enabled in the software
- No expected J1939 message from the F-Series throttle is received for more than 1.5 s
- The alarm delay timer has expired

SD480 EXTERNAL SHUTDOWN 1 ACTIVE
SD481 EXTERNAL SHUTDOWN 2 ACTIVE
SD482 EXTERNAL SHUTDOWN 3 ACTIVE
SD483 EXTERNAL SHUTDOWN 4 ACTIVE

Each individual alarm is activated when the following conditions are simultaneously met:

- The input state is “active” in accordance to its configuration (normally open or normally closed)
- The alarm delay timer has expired

The alarm delay time is adjustable for each external shutdown input individually.

AL485 LUBE OIL PRESSURE LO
SD486 LUBE OIL PRESSURE LO
AL487 LUBE OIL PRESSURE LO DERATE

The lube oil pressure engine protection functions are enabled when the following conditions are simultaneously met:

- Lube oil pressure Alarm/Derate logic is enabled (by checking the box beside “Use LOP Alarm/Derate Logic”)
- Sensed lube oil pressure sensor voltage is in range

Lube oil pressure engine protection is activated when sensed lube oil pressure is in range and falls below the user specified table of minimum oil pressure versus rpm for user specified durations. There are three levels of protection, using two thresholds and two timers. The first level is an alarm only (AL485 – Lube Oil Pressure Lo Alarm), which is activated when the sensed lube oil pressure exceeds the user specified “LOP Derate Threshold” for the user specified “LOP Alarm Delay”. The second level is a progressive (i.e. time based) engine derate (AL487 – Lube Oil Pressure Lo Derate), which derates the final engine power by the user specified “LOP Derate Stepsize” every user specified “LOP Derate Looptime” seconds that the sensed lube oil pressure exceeds the user specified “LOP Derate Threshold”. When the sensed lube oil pressure no longer exceeds “LOP Derate Threshold”, the power derate is removed by the user specified “LOP Derate Clear Stepsize” every “LOP Derate Looptime” seconds.

The third level of protection is engine shutdown (AL486 – Lube Oil Pressure LoLo Shutdown). When the power derate becomes and remains equal to or less than the user specified “LOP Derate Shutdown Threshold” for the user specified “LOP Shutdown Delay” seconds, shutdown will occur.

It is possible to configure these functions to have an alarm only, alarm with derate only, alarm with derate and shutdown, shutdown preceded by alarm, or shutdown only, by appropriately adjusting the settings.

The default configuration is for immediate shutdown only.

Note that the power derate function is intended for mechanical drive applications and is not applicable to generator applications.

AL490 LUBE OIL LEVEL LO
SD491 LUBE OIL LEVEL LO
AL492 LUBE OIL LEVEL LO DERATE

The engine oil level engine protection functions are enabled when the following condition is met:

- Engine oil level Alarm/Derate logic is enabled (by checking the box beside "Use EOL/Derate Alarm Logic")

Engine oil level protection logic will take effect when the oil level switch input indicates the oil level is low. There are two levels of protection, using two timers. The first level is an alarm (AL490 - Lube oil Level Lo Alarm) with a progressive (i.e. time based) engine derate (AL492 - Lube oil Level Lo Derate), which derates the final engine power by the user specified "EOL Derate Stepsize" every user specified "EOL Derate Looptime" seconds that low oil level is indicated. When low oil level is no longer indicated, the power derate is removed by the user specified "EOL Derate Clear Stepsize" every "EOL Derate Looptime" seconds.

The second level of protection is engine shutdown (AL491 - Lube oil Level Lo Shutdown). When the power derate becomes and remains equal to or less than the user specified "EOL Derate Shutdown Threshold" for the user specified "EOL Derate Shutdown Delay" seconds, shutdown will occur.

It is possible to configure these functions to have an alarm only, alarm with derate only, alarm with derate and shutdown, shutdown preceded by alarm, or shutdown only, by appropriately adjusting the settings.

The default configuration is for immediate shutdown only.

Note that the power derate function is intended for mechanical drive applications and is not applicable to generator applications.

AL495 COOLANT LEVEL LO
SD496 COOLANT LEVEL LO
AL497 COOLANT LEVEL LO DERATE

The engine coolant level engine protection functions are enabled when the following condition is met:

- Engine coolant level Alarm/Derate logic is enabled (by checking the box beside "Use ECL Alarm/Derate Logic")

Engine coolant level protection logic will take effect when the coolant level switch input indicates the coolant level is low. There are two levels of protection, using two timers. The first level is an alarm AL495 (Coolant level Lo Alarm) with a progressive (i.e. time based) engine derate AL497 (Coolant Level Lo Derate), which derates the final engine power by the user specified "ECL Derate Stepsize" every user specified "ECL Derate Looptime" seconds that low oil level is indicated. When low coolant level is no longer indicated, the power derate is removed by the user specified "ECL Derate Clear Stepsize" every "ECL Derate Looptime" seconds.

The second level of protection is engine shutdown AL496 (Coolant Level Lo Shutdown). When the power derate becomes and remains equal to or less than the user specified “ECL Derate Shutdown Threshold” for the user specified “ECL Derate Shutdown Delay” seconds, shutdown will occur.

It is possible to configure these functions to have an alarm only, alarm with derate only, alarm with derate and shutdown, shutdown preceded by alarm, or shutdown only, by appropriately adjusting the settings.

The default configuration is for immediate shutdown only.

Note that the power derate function is intended for mechanical drive applications and is not applicable to generator applications.

AL700 RATEGROUP SLIP
AL701 PCMHD HIGH TEMPERATURE
AL702 PCMHD EEPROM PRIMARY FLT
AL703 PCMHD EEPROM SECONDARY FLT

These alarms provide detection and warning of E3 controller self-diagnosed internal faults.

The individual alarms are activated when the following conditions are simultaneously met:
- E3 Controller is powered up
- Condition exists
- The alarm delay timer has expired

AL701 (PCM128-HD Hi temperature) is set when the temperature on the power supply integrated circuit has exceeded 150 °C.

There are no user-calibratible parameters for these alarms.

SD800 EASYGEN CAN WATCHDOG TIMEOUT

This shutdown provides detection and warning of an E3 controller diagnosed communications fault when using the easYgen-3000 controller with J1939 communications

This alarm is activated when the following conditions are simultaneously met:
- easYgen-3000 with J1939 is enabled in the software
- No expected J1939 messages from the easYgen-3000 module are received for more than 2 s.
- The alarm delay timer has expired

AL801 EASYGEN STOP COMMAND

This alarm identifies an easYgen generated shutdown command when using the easYgen-3000 controller with J1939 communications

This alarm is activated when the following conditions are simultaneously met:
- easYgen-3000 with J1939 is used in the system, and enabled in the software
- The easYgen generates a shutdown command which is received by the E3 controller
- The alarm delay timer has expired

Since the easYgen Shutdown command is a normal and expected occurrence, AL801 does not result in activation of the E3 Lean Burn Trim shutdown relay output. Also, AL801 does not get logged in the Event List. If the easYgen Shutdown command was due to an abnormal condition detected by easYgen, there will be an indication of this on the easYgen user interface.

SD920 IC920 CAN WATCHDOG TIMEOUT

This shutdown provides detection and warning of an IC-920/-922 ignition controller J1939 timeout.

This alarm is activated when the following conditions are simultaneously met:
- An IC-920/-922 ignition controller with J1939 capability is enabled in the software
- No expected J1939 message from the IC-920/-922 is received for more than 10 s
- The alarm delay timer has expired

AL1000 IC920 ERR MISS RING GEAR SIG

This alarm identifies an IC-920/922 diagnosed speed sensor fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- IC-920/922 does not detect a signal on this input OR the ring gear does not have the user defined number of teeth

AL1001 IC920 ERR MISS RST SIG

This alarm identifies an IC-920/922 diagnosed reset/TDC signal fault. The reset sensor counts the number of ignition events between two cam signals. When the expected number of ignition events does not match the detected number of events, the alarm is activated.
The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- IC-920/922 does not detect a reset signal on this input OR the number of detected ignition events between cam pulses does not match the expected number of events.

AL1002 IC920 ERR MISS CAM SIG

This alarm identifies an IC-920/922 diagnosed camshaft signal fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- IC-920/922 does not detect a signal on this input OR the ring gear does not have the user defined number of teeth

AL1003 IC920 ERR NUM OF GEAR TEETH

This alarm identifies an IC-920/922 diagnosed fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The number of teeth detected by the IC-920/922 does not match the user defined number

AL1004 IC920 UKN ENGINE APPL CODE

This alarm identifies an IC-920/922 diagnosed internal fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The firmware loaded into the IC-920/922 is not correct.

AL1005 IC920 OVERSPEED SHUTDOWN

This alarm identifies an IC-920/922 diagnosed fault. The alarm message is sent to the E3 controller via the J1939 link.
This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- Measured engine speed exceeds the user defined overspeed threshold

AL1006 IC920 EEPROM CHECKSUM ERROR

This alarm identifies an IC-920/922 diagnosed internal fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- Checksum calculated by the IC-920/922 module does not match the checksum of the IC-920/922 software

AL1007 IC920 GLOB TIM OUT OF RANGE

This alarm identifies an IC-920/922 diagnosed fault in the received timing command. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- Global timing set point received from the E3 controller is outside the specified range of –200 to 301.99 CAD

AL1008 IC920 UKN GLOB TIM OR ENERGY

This alarm identifies an IC-920/922 diagnosed fault in the received timing or energy command. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- J1939 data received from the E3 controller does not match the expected data

AL1009 IC920 IND TIMING OUT OF RANGE

This alarm identifies an IC-920/922 diagnosed fault in the individual cylinder timing data. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The individual timing set points for one of the cylinders is out of the specified range of –3 to +3 degrees CA. (Note, the individual timing cannot be tuned in the E3 HMI application).

AL1010 IC920 OPEN PRIM RATE EXCEED

This alarm identifies an IC-920/922 diagnosed fault. The alarm message is sent to the E3 controller via the J1939 link.

The IC-920/922 can detect an open circuit of its ignition output. The rate (frequency) of open circuit events is monitored, e.g., when a 8 cylinder engine runs at 1500 rpm:

1500/60 = 25 revolutions/s
25/2 = 12.5 firings per cylinder/s
So when the Total Open Primary rate = 25 / sec this means that 2 coils have an open circuit.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The detected number of open circuits per second exceeds the configured level in the IC-920/922

AL1011 IC920 WAIT FOR 0 SPEED

This alarm identifies an IC-920/922 diagnosed sequencing fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The IC-920/922 detects engine speed without being enabled/firing, e.g. during cranking of the engine

AL1012 IC920 OPEN PRIMARY CHANNEL 1
AL1013 IC920 OPEN PRIMARY CHANNEL 2
AL1014 IC920 OPEN PRIMARY CHANNEL 3
AL1015 IC920 OPEN PRIMARY CHANNEL 4
AL1016 IC920 OPEN PRIMARY CHANNEL 5
AL1017 IC920 OPEN PRIMARY CHANNEL 6
AL1018 IC920 OPEN PRIMARY CHANNEL 7
AL1019 IC920 OPEN PRIMARY CHANNEL 8
AL1020 IC920 OPEN PRIMARY CHANNEL 9
AL1021 IC920 OPEN PRIMARY CHANNEL 10
AL1022 IC920 OPEN PRIMARY CHANNEL 11
AL1023 IC920 OPEN PRIMARY CHANNEL 12
AL1024 IC920 OPEN PRIMARY CHANNEL 13
AL1025 IC920 OPEN PRIMARY CHANNEL 14
AL1026 IC920 OPEN PRIMARY CHANNEL 15
AL1027 IC920 OPEN PRIMARY CHANNEL 16
AL1028 IC920 OPEN PRIMARY CHANNEL 17
AL1029 IC920 OPEN PRIMARY CHANNEL 18
AL1030 IC920 OPEN PRIMARY CHANNEL 19
AL1031 IC920 OPEN PRIMARY CHANNEL 20

This alarm identifies an IC-920/922 diagnosed fault in the ignition coil primary circuits. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:

- IC-920/922 with J1939 is installed in the system, and enabled in the software
- Ignition output (1-20) is enabled in the IC-920/922 software
- Open circuit is detected on this ignition output.

AL1032 IC920 WARN MISS RING GEAR SIG

This alarm identifies an IC-920/922 diagnosed ring gear signal fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:

- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The ring gear speed sensor signal is missing or has an incorrect tooth count compared to the programmed number of teeth.

AL1033 IC920 WARN MISS RESET SIG

This alarm identifies an IC-920/922 diagnosed reset signal fault. The alarm message is sent to the E3 controller via the J1939 link.
This alarm is activated when the following conditions are simultaneously met:

- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The Reset/TDC sensor signal is missing or the detected number of reset pulses between two successive cam pulses is incorrect

AL1034 IC920 WARN MISS CAM SIG

This alarm identifies an IC-920/922 diagnosed camshaft sensor signal fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The Phase (camshaft) sensor signal is missing or the detected number of cam pulses between three successive reset pulses is incorrect

AL1035 IC920 ODD ENGY LVL OUT OF RNG

This alarm identifies an IC-920/922 diagnosed ignition energy level fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The energy level for the odd cylinders received from the E3 controller by the IC-920/922 module is outside the range of 10 to 100%.

AL1036 IC920 EVEN ENGY LVL OUT OF RNG

This alarm identifies an IC-920/922 diagnosed ignition energy level fault. The alarm message is sent to the E3 controller via the J1939 link.

This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- The energy level for the even cylinders received from the E3 controller by the IC-920/922 module is outside the range of 10 to 100%.

AL1037 IC920 SCR FAULT ODD

This alarm identifies an IC-920/922 diagnosed SCR fault. The alarm message is sent to the E3 controller via the J1939 link.
This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- an unexpected firing event is detected in one of the odd cylinders.

AL1038 IC920 SCR FAULT EVEN

This alarm identifies an IC-920/922 diagnosed SCR fault. The alarm message is sent to the E3 controller via the J1939 link.
This alarm is activated when the following conditions are simultaneously met:
- IC-920/922 with J1939 is installed in the system, and enabled in the software
- an unexpected firing event is detected in one of the even cylinders.

SD1300 THROTTLE1 SHUTDOWN

This shutdown identifies a diagnosed internal shutdown fault on the J1939 configured Throttle1.

This alarm is activated when the following conditions are simultaneously met:
- Throttle1 with J1939 is used as mixture throttle, and enabled in the software
- Throttle1 diagnostics logic detects an internal fault.

The Throttle1 Actuators requires a reset over the “Run Enable contact” or power cycle to clear this fault.

AL1301 THROTTLE1 ALARM

This alarm identifies a diagnosed internal alarm fault on the J1939 configured Throttle1.

This alarm is activated when the following conditions are simultaneously met:
- Throttle1 with J1939 is used as mixture throttle, and enabled in the software
- Throttle1 diagnostics logic detects an internal fault.

The Throttle1 Actuators requires a reset over the “Run Enable contact” or power cycle to clear this fault.

AL1305 THROTTLE1 POSITION ERROR
SD1305 THROTTLE1 POSITION ERROR

This alarm or shutdown identifies a diagnosed internal alarm fault on the J1939 configured Throttle1.

This alarm is activated when the following conditions are simultaneously met:
- Throttle1 with J1939 is used as mixture throttle, and enabled in the software
- Throttle1 position feedback does not follow the position demand. This can be a difference between the TPS1 value and the position demand or the internal position error from a J1939 configured actuator.

SD1308 THROTTLE1 WATCHDOG CAN TIMEOUT

This shutdown is activated when the following conditions are simultaneously met:

- Throttle1 with J1939 capability is used as fuel trim valve 1 in the system
- Throttle1 with J1939 capability is enabled in the software
- No expected J1939 message from the fuel trim valve is received for more than 1.5 s
- the alarm delay timer has expired

SD1310 THROTTLE2 SHUTDOWN

This shutdown identifies a diagnosed internal shutdown fault on the J1939 configured Throttle2.

This alarm is activated when the following conditions are simultaneously met:
- Throttle2 with J1939 is used as mixture throttle, and enabled in the software
- Throttle2 diagnostics logic detects an internal fault.

The Throttle2 Actuators requires a reset over the “Run Enable contact” or power cycle to clear this fault.

AL1311 THROTTLE2 ALARM

This alarm identifies a diagnosed internal alarm fault on the J1939 configured Throttle2.

This alarm is activated when the following conditions are simultaneously met:
- Throttle2 with J1939 is used as mixture throttle, and enabled in the software
- Throttle2 diagnostics logic detects an internal fault.

The Throttle2 Actuators requires a reset over the “Run Enable contact” or power cycle to clear this fault.

AL1315 THROTTLE2 POSITION ERROR
SD1315 THROTTLE2 POSITION ERROR

This alarm or shutdown identifies a diagnosed internal alarm fault on the J1939 configured Throttle2.

This alarm is activated when the following conditions are simultaneously met:
- Throttle2 with J1939 is used as mixture throttle, and enabled in the software
- Throttle2 position feedback does not follow the position demand. This can be a difference between the TPS2 value and the position demand or the internal position error from a J1939 configured actuator.

SD1318 THROTTLE2 WATCHDOG CAN TIMEOUT

This shutdown is activated when the following conditions are simultaneously met:

- Stereo Engine is configured.
- Throttle2 with J1939 capability is used as throttle in the system
- Throttle2 with J1939 capability is enabled in the software
- No expected J1939 message from the fuel trim valve is received for more than 1.5 s
- The alarm delay timer has expired

SD1320 FTV 1 SHUTDOWN

This shutdown identifies a diagnosed internal shutdown fault on the J1939 configured FTV 1.

This alarm is activated when the following conditions are simultaneously met:
- FTV1 with J1939 is used as mixture FTV, and enabled in the software
- FTV1 diagnostics logic detects an internal fault.

The FTV 1 Actuators requires a reset over the “Run Enable contact” or power cycle to clear this fault.

AL1321 FTV 1 ALARM

This alarm identifies a diagnosed internal alarm fault on the J1939 configured FTV 1.

This alarm is activated when the following conditions are simultaneously met:
- FTV1 with J1939 is used as mixture FTV, and enabled in the software
- FTV1 diagnostics logic detects an internal fault.

The FTV 1 Actuators requires a reset over the “Run Enable contact” or power cycle to clear this fault.

AL1325 FTV 1 POSITION ERROR
SD1325 FTV 1 POSITION ERROR

This alarm or shutdown identifies a diagnosed internal alarm fault on the J1939 configured FTV 1.

This alarm is activated when the following conditions are simultaneously met:

- FTV1 with J1939 is used as mixture FTV, and enabled in the software
- FTV 1 position feedback does not follow the position demand. This can be a difference between the TPS1 value and the position demand or the internal position error from a J1939 configured actuator.

SD1328 FTV 1 WATCHDOG CAN TIMEOUT

This shutdown is activated when the following conditions are simultaneously met:

- FTV1 with J1939 capability is used as fuel trim valve 1 in the system
- FTV1 with J1939 capability is enabled in the software
- No expected J1939 message from the fuel trim valve is received for more than 1.5 s
- The alarm delay timer has expired

SD1330 FTV 2 SHUTDOWN

This shutdown identifies a diagnosed internal shutdown fault on the J1939 configured FTV 2.

This alarm is activated when the following conditions are simultaneously met:

- FTV2 with J1939 is used as mixture FTV, and enabled in the software
- FTV2 diagnostics logic detects an internal fault.

The FTV 2 Actuators requires a reset over the “Run Enable contact” or power cycle to clear this fault.

AL1331 FTV 2 ALARM

This alarm identifies a diagnosed internal alarm fault on the J1939 configured FTV 2.

This alarm is activated when the following conditions are simultaneously met:

- FTV2 with J1939 is used as mixture FTV, and enabled in the software
- FTV2 diagnostics logic detects an internal fault.

The FTV 2 Actuators requires a reset over the “Run Enable contact” or power cycle to clear this fault.

AL1335 FTV 2 POSITION ERROR
SD1335 FTV 2 POSITION ERROR

This alarm or shutdown identifies a diagnosed internal alarm fault on the J1939 configured FTV 2.

This alarm is activated when the following conditions are simultaneously met:

- FTV2 with J1939 is used as mixture FTV, and enabled in the software
- FTV 2 position feedback does not follow the position demand. This can be a difference between the TPS2 value and the position demand or the internal position error from a J1939 configured actuator.

SD1338 FTV 2 WATCHDOG CAN TIMEOUT

This shutdown is activated when the following conditions are simultaneously met:

- Stereo Engine is configured.
- FTV2 with J1939 capability is used as FTV in the system
- FTV2 with J1939 capability is enabled in the software
- No expected J1939 message from the fuel trim valve is received for more than 1.5 s
- The alarm delay timer has expired

AL1401 CYLINDER 1 OPEN CIRCUIT
SD1401 CYLINDER 1 OPEN CIRCUIT
AL1402 CYLINDER 2 OPEN CIRCUIT
SD1402 CYLINDER 2 OPEN CIRCUIT
AL1403 CYLINDER 3 OPEN CIRCUIT
SD1403 CYLINDER 3 OPEN CIRCUIT
AL1404 CYLINDER 4 OPEN CIRCUIT
SD1404 CYLINDER 4 OPEN CIRCUIT
AL1405 CYLINDER 5 OPEN CIRCUIT
SD1405 CYLINDER 5 OPEN CIRCUIT
AL1406 CYLINDER 6 OPEN CIRCUIT
SD1406 CYLINDER 6 OPEN CIRCUIT
AL1407 CYLINDER 7 OPEN CIRCUIT
SD1407 CYLINDER 7 OPEN CIRCUIT
AL1408 CYLINDER 8 OPEN CIRCUIT
SD1408 CYLINDER 8 OPEN CIRCUIT

These alarms provide detection and warning of an E3 controller diagnosed primary circuit fault when using Smart Coil ignition. These alarms can only be set during system power-up.
This alarm is activated when the following conditions are simultaneously met:

- Smart Coils are enabled in the software
- Engine is not running
- Less then 1 second has elapsed since power was applied to key switch
- Open circuit is detected on the coil primary side (E3 controller output)
- The alarm delay timer has expired

AL1411 CYLINDER 1 SHORT CIRCUIT
SD1411 CYLINDER 1 SHORT CIRCUIT
AL1412 CYLINDER 2 SHORT CIRCUIT
SD1412 CYLINDER 2 SHORT CIRCUIT
AL1413 CYLINDER 3 SHORT CIRCUIT
SD1413 CYLINDER 3 SHORT CIRCUIT
AL1414 CYLINDER 4 SHORT CIRCUIT
SD1414 CYLINDER 4 SHORT CIRCUIT
AL1415 CYLINDER 5 SHORT CIRCUIT

SD1415 CYLINDER 5 SHORT CIRCUIT
AL1416 CYLINDER 6 SHORT CIRCUIT
SD1416 CYLINDER 6 SHORT CIRCUIT
AL1417 CYLINDER 7 SHORT CIRCUIT
SD1417 CYLINDER 7 SHORT CIRCUIT
AL1418 CYLINDER 8 SHORT CIRCUIT
SD1418 CYLINDER 8 SHORT CIRCUIT

These alarms provide detection and warning of an E3 controller diagnosed coil primary circuit fault when using Smart Coil ignition

This alarm is activated when the following conditions are simultaneously met:

- Smart Coils are enabled in the software
- The engine is rotating and spark signals are being sent to the Smart Coils
- Short circuit is detected on the coil primary side (E3 controller output)
- The alarm delay timer has expired

SD1430 ALL COILS OPEN CIRCUIT FLT

This alarm provides detection and warning of an E3 controller diagnosed primary circuit fault when using Smart Coil ignition
This alarm is activated when the following conditions are simultaneously met:

- Smart Coils are enabled in the software
- Engine is not running
- Less then 1 second has elapsed since power was applied to key switch
- Open circuit is detected on coil primary side of all coils (E3 controller output)
- The alarm delay timer has expired

SD1440 ALL COILS SHORT CIRCUIT FLT

This alarm provides detection and warning of an E3 controller diagnosed primary circuit fault when using Smart Coil ignition

This alarm is activated when the following conditions are simultaneously met:

- Smart Coils are enabled in the software
- The engine is rotating and spark trigger signals are being sent to the Smart Coils
- Short circuit is detected on coil primary side of all coils (E3 controller output)
- The alarm delay timer has expired

Chapter 6. Control Wiring Diagram

The E3 Lean Burn Trim control wiring diagram, documents 9971-1266, is reproduced below. This document is available from Woodward on request. Note that all system and wiring options are shown. Wiring of individual installations will be reduced from that shown.

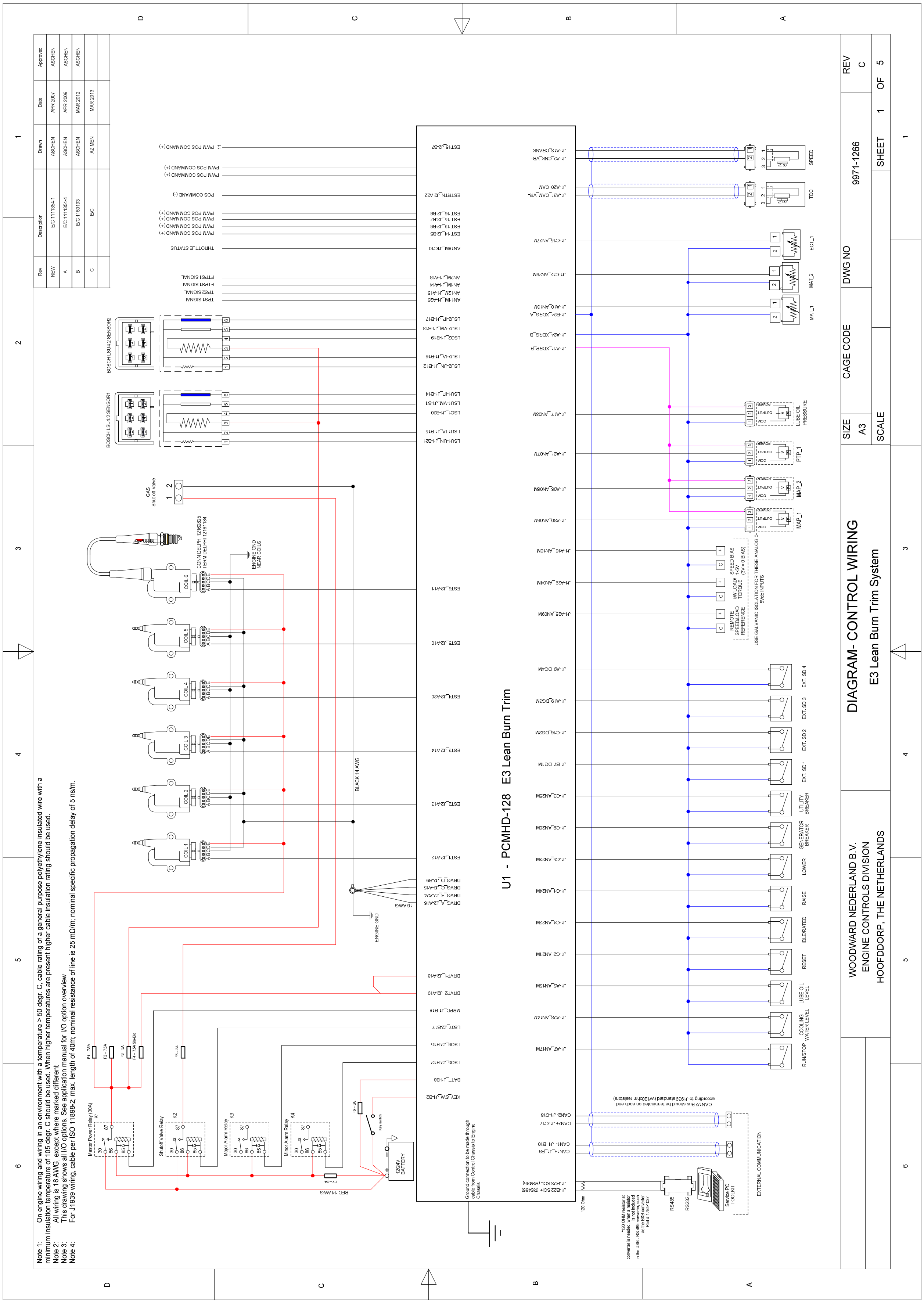


DIAGRAM- CONTROL WIRING
E3 Lean Burn Trim System
U1 - PCMHD-128 E3 Lean Burn Trim
WOODWARD NEDERLAND B.V.
ENGINE CONTROLS DIVISION
HOOFDDORP, THE NETHERLANDS
DWG NO 9971-1266
SIZE A3
REV C
SHEET 1 OF 5
Note 1: On engine wiring and wiring in an environment with a temperature > 50 degr. C, cable rating of a general purpose polyethylene insulated wire with a minimum insulation temperature of 105 degr. C should be used. When higher temperatures are present higher cable insulation rating should be used.
Note 2: All wiring is 18 AWG, except where marked different.
Note 3: This drawing shows all I/O options. See application manual for I/O option overview.
Note 4: For J1939 wiring, cable per ISO 11898-2; max. length of 40m; nominal resistance of line is 25 mΩ/m; nominal specific propagation delay of 5 ns/m.

Chapter 7.
Software Revisions

This chapter describes the various software differences between the different versions of the control that have been released over the life of the control.

8237-1266
Software PN 5601-1097 B
Updated to coder 5.02, no functional updates.

8237-1272
Software PN 5601-1096 A
5601-1096 B
Updated to coder 5.02, no functional updates.
5601-1096 C
Updated software to coder 5.04, add PISC J1939 throttle, Updated new Misfire Logic
5601-1096D

8280-1158 w/o Speed Control/8280-1159 w/Speed Control

Woodward engineers will go to new part numbers when the form, fit, or function of the control has significantly changed. This revision includes a removal of support of the now obsolete Woodward Firefly knock detection system.

Loading Settings from Previous Revisions:
When loading settings you must load the setting twice. The first time includes an adjustment of the communication speed that will cause your control to disconnect. On the second attempt to load settings they will load as completely as possible.

Settings that need to be adjusted after a reload of an older versions settings include but may not be limited to:

- Page 0.1
  - "ACTUATOR SELECT" to select the output type for each actuator.
  - "MODE" under "BATTERY CONSERVATION"
  - "CAN PROACT CONFIGURATION"
- Page 0.2
  - "Engine Sr. Number"
- Page 1.3- LAMBDA 1 CLOSED LOOP CONTROL SETTINGS
  - Max. CL Correction +
  - Min. CL Correction -
- Page 1.4 GAS QUALITY CLOSED LOOP – INLINE CONFIG ONLY
  - Max. CL Correction +
  - Min. CL Correction –
    - These values used to a be a single symmetric tunable, but now can be set independently.
  -
- Page 1.6- LAMBDA 2 CLOSED LOOP CONTROL SETTINGS
  - Max. CL Correction +
  - Min. CL Correction -
    - These values were a single symmetric tunable, but now can be set independently.

- Page 4.9
    - “Pattern”
- Page 5.1 – MISFIRE
    - “Off Grid Fault Settings”
    - “On Grid Fault Settings”
- Page 8.1-10
    - Any faults that were overridden
    - Any fault Alarm/Shutdown action that was changed from the defaults

Feature Changes:

1. The Woodward Firefly Knock Detection software has been removed from the control.

2. The control software has been updated to allow usage on “Stereo Engines” (engines with two independent Air/Fuel management systems). There is a tunable value on page 0.1 CONFIGURATION called “Engine Config” that sets the control configuration to either “INLINE ENGINE” or “STEREO ENGINE”. The selection will determine what values are displayed in the Toolkit service tool automatically allowing configuration of the values needed for either engine configuration.

3. The De-rate function in the control related to Manifold Air Temperature was enhanced.

4. The runtime clock in the E3 was not built using a “Real time clock.” The software has been reworked to provide runtime accuracy of +/- 0.2%.

5. The UEGO Air Calibration could return different “Sensor gains” for the same sensor each time a calibration process was performed. The air calibration procedure internal to the software was re-worked so that the calibration is more accurate.

6. The control manual has been embedded into the service tool. Select “Help” and then the “E3 LBT Manual 26464” selection to reference the manual.

7. When a user selects a 0.0 speed filter value the 5 ms rate group block still acts as a filter.

8. The J1939 CAN messages from the IC-92X ignitions for AL_1035 and AL1037 were switched. The J1939 CAN messages from the IC-92X ignitions for AL_1036 and AL1038 were switched. Both sets of diagnostic messages have been re-addressed correctly.

9. The speed control gain Ratios could be set to values <1.0. Gain Ratios are a multiplier on the Proportional Gain term and are designed only for values >1.0.

10. DIAG.AL_75_S.B_ALARM did not go to the First Shutdown counter as of this revision it is connected.

11. The current control uses a checkbox to reset faults. This required two mouse clicks for the user. One to perform the reset action and a section to arm the logic. Implement momentary button code for “Reset” Button in Toolkit. As of this revision a self arming block has been implemented in the Toolkit to reset Faults and the CAN bus.

12. The CAN ID structure for the F-series actuators did not follow the specifications in the F-series documentation. The CAN ID information has been re-worked to make it consistent with the F-series documentation.

13. Advances in the Woodward Misfire modeling have developed a value that has a higher signal to noise to ratio and support up to 16 (from the previous recommended limit of 8). As of this revision “C” the calculated value fed into the fault logic has been updated to the improved calculation. Typical values on Woodward commissioned engines have been 0.15 for a background signal, 0.5 for a partial misfire, 1.2 for a complete misfire. The fault detection capabilities have also been improved with separate alarm tables for “On Grid” and “Off Grid” settings for running in island mode. The default Alarm and Shutdown levels have been updated to reflect the improved algorithm.

    a. Misfire Detected Status now compares the current misfire level to the “Alarm Settings” values with permissives for the “Engine Running”, “Key Switch Powered”, and “Map%” >”Minimum MAP% for Misfire Detection”.

    b. The “Number of Cylinders” has been moved from the 5.1 Misfire to page 4.9 INPUT (SPEED SENSORS) as the speed from the misfire block is used to create the filter for the speed used for speed control and the for the analog misfire value use for fault detection.

14. The speed measurement configuration password level has been lowered from 4 to 3.

15. The control software has been updated to allow usage of 12 Vdc systems to power the E3 controller. When using a 12 Vdc supply the low voltage and high voltage fault thresholds will need to be adjusted from the default settings.

16. In previous software versions all faults annunciated as AL_XYZ. Alarms will now be annunciated with AL_XYZ and Shutdowns will be annunciated with SD_ABC

17. DM messages were not supported for J1939 systems. The control software now supports DM1, DM3, and DM11 messages.

18. The serial communication link was set to 56 kb/s and has increased to 115 kb/s for faster communication.

19. When running in stereo engine mode GQCL is disabled.

20. The default table for the Exhaust back pressure table has been updated with new default values.

21. The trim and throttle valves can now have their default directions reversed by using the service tool.

22. The control now supports independent AFR control for engines with two carburetors (Stereo engines). The speed control will also perform load balancing per bank for engines equipped with two throttle actuators.

23. The software has been updated to allow entering letters into the “Engine Serial Number” field.

24. AL90 and 100 were shown with text of "PMECH INPUT" in the "Event List", when there was no "PMECH INPUT" called out in the service tool it was called "LOAD SENSOR". The text in "Event List" has been updated to include "LOAD SENSOR" in the description of the faults.

25. On 20 channel IC-920s PGN 65524 shows a fault on cylinder 21-24 because they don't exist, e3 flags this as a watchdog timeout and can't be overridden. Errors for these timing signals have been removed from the Watchdog timeout fault actions.

26. All CAN watchdog timeouts are now shutdowns.

27. J1939 CAN messages have been added to the control to enable an operator to make UEGO and GQCL settings richer or leaner. The configuration for the amount each "Make Rich" or "Make Lean" pulse changes the set point is defaulted to 0.02 Lambda per pulse and is tunable on pages 1.2 and 1.4. In addition a total of all the manual biases have been added to this page.

28. Making a change to "Page 4.9 – INPUT (SPEED SENSORS)" the end user must re-boot the control for the changes to take place. In order to make 100% sure that any change to the configuration values on this page result in a control reboot the ability to adjust the values has been moved to an "Offline Editor button" in the Toolkit.

29. There was no load permissive for the Lambda Closed Loop using the UEGO inputs. This could allow the unit to go into closed loop while the engine was performing an extended idle time. There is now a load% permissive that either uses kW divided max kW or MAP divided by MAP reference depending on whether the control is in Generator or All Speed (compressor) mode defaulted to 40%.

30. In order to support Stereo Engines a tunable value called "Engine Config" has been added. This value will disable faults/control functions related to Stereo engines when "Mono Engine" is selected. In addition the service tool has been updated to only show the values relative to the selected "Engine Config".

31. All E3 compatible Woodward actuator have 0–5 Vdc position sensors. Prior to Revision "C" the only supported position sensor was for the Throttle actuator on pin J1-A26. This signal has been termed "TPS1". Additionally three more inputs have been configured for the Stereo engines second throttle "TPS2" and for the two available fuel trim valves "FTPS1" and "FTPS2". These inputs are only meant to be used with PWM demand signals. If using CAN the position of the valves and faults is done using the CAN messages related to the internal diagnostics of the Smart Actuator.

32. Prior to this revision only J1939 CAN was supported for external devices to monitor control parameters. As of this revision there is a display available from the Woodward RERs that takes the J1939 CAN messages and converts them to Modbus. The display also allows end users to monitor the condition of the engine, acknowledge any faults if present, and make Air Fuel ratio adjustments without use of a PC

33. The control has been updated to allow use-age of more demand signals for the Woodward family of Smart Actuators.

Actuator Name	Rev. A&B Supported Demand Signals		8280-1158/1159 Demand Signals	
	CAN	PWM	CAN	PWM
L-series		X	NA	X
F-series		X	X	X
ProAct Digital Plus		X	X	X
ProAct ISC	X		X	NA
P-series		X	X	X

34. In order to calibrate the actuators there is a calibration procedure on each actuators setup page. When calibrating the actuators must be in “Run” mode. As of this revision when calibration mode is enable on any of the four possible actuators the MPRD output will go “True” for its configured delay timer (default 300 seconds).

35. The Barometric pressure capture logic was reworked to eliminate nuisance faults.

36. An automatic override to the barometric pressure faults was added to override the faults when the unit is GQCL (MAP vs. KW).

37. Manual reset momentary HMI points have been added for CANbus 1 and CANbus 2.

38. The service tool is now universal for both versions of the control. When the service tool connects to the controller, it identifies whether the controller has the version with or without speed control in it based on the firmware identification information. It will then display the appropriate version of the service with only the appropriate information based on the control software. For instance, when connecting to a version without speed control, the user will not see information related to throttles or speed reference.

Chapter 8.
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email (**EngineHelpDesk@Woodward.com**) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime.

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option, with the exception that the unit will be returned to you in “like-new” condition. This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:

- return number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:

- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

NOTICE

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Replacement Parts

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact.

Product Training is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at www.woodward.com/directory.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory published at www.woodward.com/directory.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used In Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used In Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used In Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

For the most current product support and contact information, please visit our website directory at www.woodward.com/directory.

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name ____________________

Site Location ____________________

Phone Number ____________________

Fax Number ____________________

Prime Mover Information

Manufacturer ____________________

Engine Model Number ____________________

Number of Cylinders ____________________

Type of Fuel (gas, gaseous, diesel, dual-fuel, etc.) ____________________

Power Output Rating ____________________

Application (power generation, marine, etc.) ____________________

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter ____________________

Control Description or Governor Type ____________________

Serial Number ____________________

Control/Governor #2

Woodward Part Number & Rev. Letter ____________________

Control Description or Governor Type ____________________

Serial Number ____________________

Control/Governor #3

Woodward Part Number & Rev. Letter ____________________

Control Description or Governor Type ____________________

Serial Number ____________________

Symptoms

Description ____________________

____

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Appendix.
Optional Operator HMI

There is an optional operator HMI available through the Woodward RER network.
http://www.woodward.com/enginecontrolsystemsupgrades.aspx

Electrical Operator HMI

Display:	FTSN
Resolution:	160 x 128 pixel
Power Requirements:	10 to 32 Vdc supply (reverse polarity protected)
Power Consumption:	40 mA (backlight off) 160 mA (backlight on) at 12 Vdc
Audible Alarm:	4 kHz Internal sounder
Wiring Protection:	Polarity reverse protected (Fuse must be included)
Connection:	Integral Deutsch 12 way connector (DT04-12PA)
Communication:	Full CAN 2.0B controller/ port. RS-232/ RS-422. RS-485
Listings:	CE, CSA Class I, Divison 2, Groups A, B, C, D

Environmental Operator HMI

Operating Temperature:	–40 °C to + 75 °C (–40 °F to 167 °F)
Storage Temperature:	–40 °C to + 80 °C (–40 °F to 176 °F)
Degree of Protection:	IP67
Salt Spray:	IEC 60068-2-52: 1996
EMC:	IEC 61000 and EN55022

Wiring callouts Operator HMI

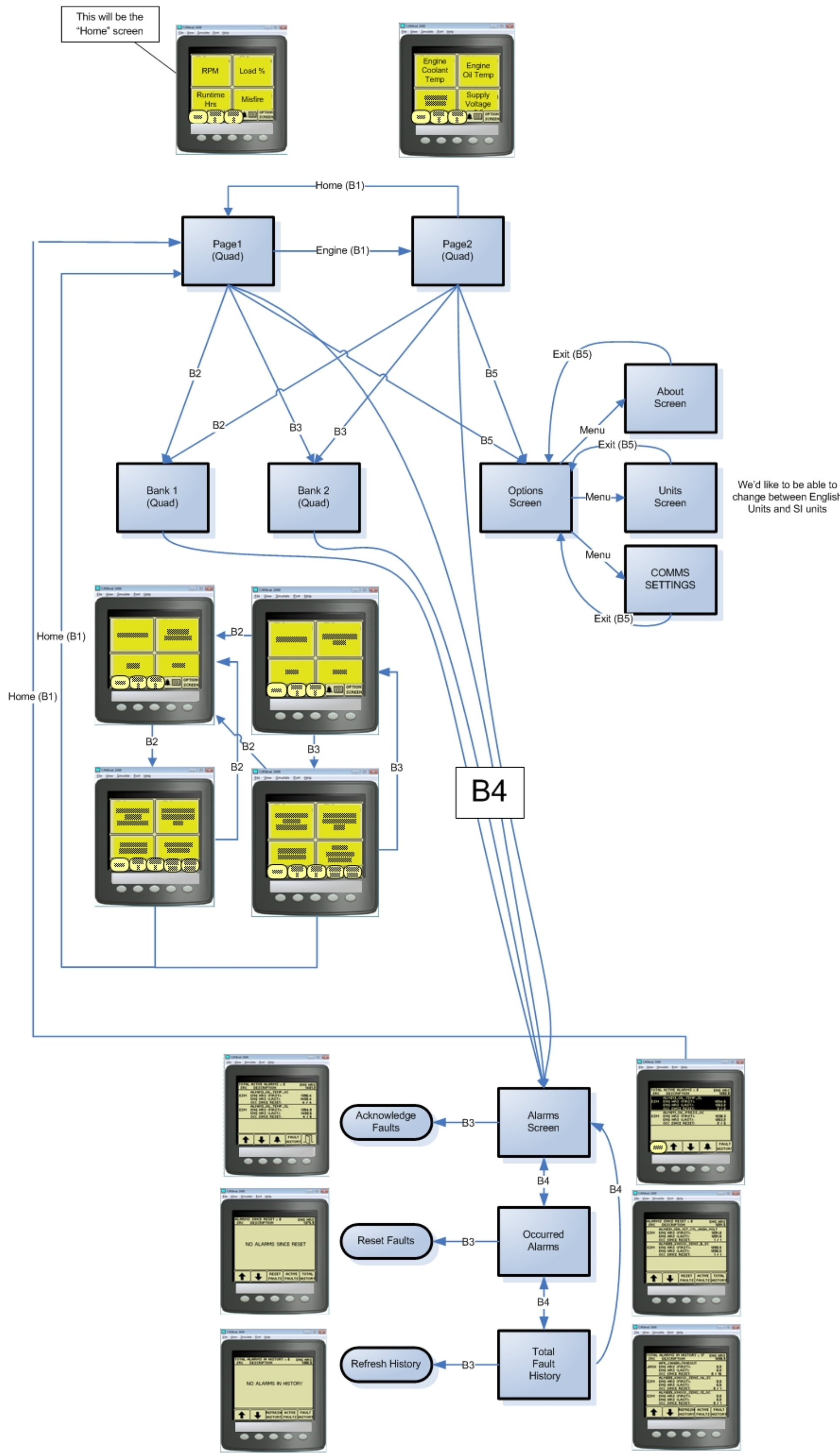
Deutsch Pin No.	
1	Power Battery minus
2	Power Battery +
3	RS-232 TX (+)
4	RS-232 TX (–)
5	RS-232 RX (–)
6	RS-232 RX (+)
7	CAN Lo
8	CAN Hi
9	RS-485A
10	RS-485B
11	Not used
12	Not used

Display: Operator HMI

Displayed Parameters Operator HMI

	Reads from or Writes to E3 Control	PGN	Parameter Group Label	Transmission Rate (ms)	J1939 Standard Name	Units
Engine P1	**Read**	61444	Electronic Engine Controller 1	500	Engine Speed	rpm
Engine P1	**Read**	61443	Electronic Engine Controller 2	500	Engine Percent Load At Current Speed	%
Engine P1	**Read**	65253	Engine Hours, Revolutions	500	Engine Total Hours of Operation	Seconds
Engine P1	**Read**	65283	Misfire	500	Misfire	RPM/SEC^2
Engine P2	**Read**	65262	Engine Temperature 1	500	Engine Coolant Temperature	C
Engine P2	**Read**	65271	Vehicle Electrical Power 1	500	Keyswitch Battery Potential	Volts
Engine P2	**Read**	65262	Engine Temperature 1	500	Engine Oil Temperature 1	C
Engine P2	**Read**	65263	Engine Fluid Level/Pressure 1	500	Engine Oil Pressure	kPa
Bank1 P1	**Read**	61443	Electronic Engine Controller 2	500	Accelerator Pedal Position 1	%
Bank1 P1	**Read**	65153	Fuel Information 2 (Gaseous)	500	Engine Fuel Valve 1 Position	%
Bank1 P1	**Read**	65270	Intake/Exhaust Conditions 1	500	Engine Intake Manifold #1 Pressure	kPa
Bank1 P1	**Read**	65270	Intake/Exhaust Conditions 1	500	Engine Intake Manifold 1 Temperature	C
Bank1 P2	**Read**	65193	Exhaust Oxygen 1	500	Engine Desired Exhaust Oxygen	%
Bank1 P2	**Read**	65193	Exhaust Oxygen 1	500	Engine Actual Exhaust Oxygen	%
Bank1 P2	**Read**	65193	Exhaust Oxygen 1	500	Engine Exhaust Gas Oxygen Sensor Fueling Correction	%
Bank1 P2	**Read**	65312	Proprietary B	500	Manual Bias Bank 1 Total	%
Bank1 P2	**Write**	65313	Proprietary B	500	Manual Increment Rich Bank 1	
Bank1 P2	**Write**	65313	Proprietary B	500	Manual Increment Lean Bank 1	
Bank 2 P1	**Read**	61443	Electronic Engine Controller 2	500	Accelerator Pedal Position 2	%
Bank 2 P1	**Read**	65153	Fuel Information 2 (Gaseous)	500	Engine Fuel Valve 2 Position	%
Bank 2 P1	**Read**	64976	Intake/Exhaust Conditions 2	500	Engine Intake Manifold #2 Pressure	kPa
Bank 2 P1	**Read**	65189	Intake Manifold Information 2	500	Engine Intake Manifold 2 Temperature	C
Bank 2 P2	**Read**	65312	Proprietary B	500	Engine Desired Exhaust Oxygen 2	%
Bank 2 P2	**Read**	65312	Proprietary B	500	Engine Actual Exhaust Oxygen 2	%
Bank 2 P2	**Read**	65312	Engine Exhaust Bank 2 O2 Fuel Trim	500	Long-term Fuel Trim - Bank 2	%
Bank 2 P2	**Read**	65312	Proprietary B	500	Manual Bias Bank 2 Total	%
Bank 2 P2	**Write**	65313	Proprietary B	500	Manual Increment Rich Bank 2	
Bank 2 P2	**Write**	65313	Proprietary B	500	Manual Increment Lean Bank 2	

Screen Navigation Operator HMI



Engine Operator HMI

Bank 1 Operator HMI

To enable the "Make Rich" or "Make Lean" function you must enter the tuning password "1111". This password can be customized through the system sub-menu to a user defined value.

Important: If the default password is changed, the only way it can be reset is by Woodward service personnel reloading the screen application firmware.

There is a timeout for entering "Make Rich" and "Make Lean" adjustments that ensures the control will not be able to have the AFR settings adjusted if the technician that entered the password walks away from the unit.

Bank 2 Operator HMI

To enable the “Make Rich” or “Make Lean” function you must enter the tuning password “1111”. This password can be customized through the system sub-menu to a user defined value.

Important: If the default password is changed, the only way it can be reset is by Woodward service personnel reloading the screen application firmware.

There is a timeout for entering “Make Rich” and “Make Lean” adjustments that ensures the control will not be able to have the AFR settings adjusted if the technician that entered the password walks away from the unit.

Active Alarm Lists

When an active/current alarm is received, a flashing pop-up window appears overlaid on the current screen in use, showing details of the current alarm. When an active alarm is received, the Engine Monitor activates its internal sounder.

Example alarm message, plus alarm list screens showing unacknowledged conditions (black background) and acknowledged alarms (grey background). After acknowledgement, the exit key (open door icon) becomes active. J1939-standard abbreviations are used wherever possible, Note. “MS” = Most Severe, “MOD”= Moderately Severe and “LS” = Least Severe.

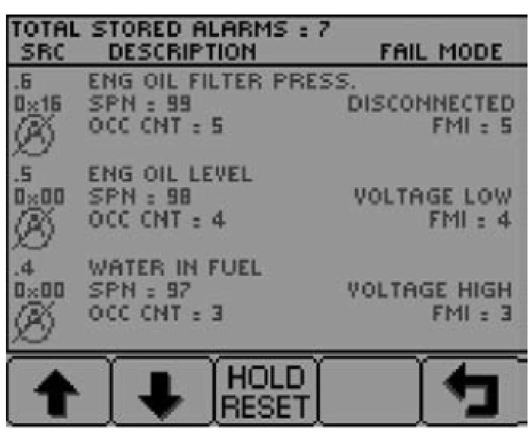
The alarm list is accessed by pressing any key while an alarm pop-up is displayed, or by pressing any of the first 4 keys to show the button bar, and then key 4. This screen displays all current active alarms; when entered, Alarms not yet acknowledged are shown in grey on black. Alarms already acknowledged are shown in black on grey. If engine hours data is available, the list indicates when the alarm was initiated.

When first entering the screen, the list automatically displays the most recent alarm. The list can be scrolled using keys 1 and 2. This screen cannot be exited until all alarms have been acknowledged by pressing key 3. Alarm messages are automatically cleared from the list when no longer received by the E3.

Pressing button 3 (the bell) will acknowledge the alarm in the HMI and turn off the buzzer. Holding the Bell for 3 seconds will send a reset command to the E3.

Stored Alarm Lists - continued

Alarms stored by engine/transmission ECU’s (i.e. not active or current but old/ historical alarms) may be viewed by pressing and holding key 4 while the active alarm list screen is visible. On entry to this page, the Engine Monitor sends a data request to the engine/transmission. The engine/transmission sends the stored alarm data to the Engine Monitor, which is decoded and displayed in a similar fashion to active alarms. The Engine Monitor displays an error message if there is no response from the engine/transmission. If the engine/ transmission supports the erasure of stored alarms, they may now be erased by holding key 3.



Configuration Menu

This mode allows users to set various Engine Monitor operating parameters such as imperial or metric units, scale limits for speedometer, engine service interval, etc. The configuration menu is entered by pressing and holding key 5 (the right hand key) for at least 3 seconds while the Engine Monitor is in normal operating mode. The top level configuration menu will be displayed as shown. Keys 1 and 2 then allow you to choose from SETTINGS, SYSTEM or Db VIEWER (The chosen item is highlighted in bold with an arrow pointing to it). Pressing key 4 enters the chosen sub-menu. SETTINGS allows the Engine Monitor to be configured according to user preferences. SYSTEM accesses maintenance and low level system configuration settings. Db VIEWER allows the user to view all data (including that that cannot be found in the graphical screens) that the engine Monitor decodes. Each of these sub-menus is described in more detail on the pages following. Pressing key 5 exits the current menu/sub-menu. Settings are automatically stored on exit.

The settings menu allows the user to enter sub-level screens to configure:
Units: This menu enables the user to set the units used for speed, distance, pressure, volume and temperature.

Modbus Operator HMI

The display reads the control parameters over the J1939 CAN2 port of the E3 control and exports those messages using the Modbus protocol on the RS-485 port (pins 9 and 10).

Modbus Settings:

- Baud Rate: 9600
- Data bits: 8
- Parity: None
- Stop Bit: 1
- Mode: RTU.

Analog Modbus Parameters

	Reads from or Writes to E3 Control	Transmission Rate (ms)	J1939 Standard Name	Units	Modbus Analog Reads	Multiplier
Engine P1	Read	500	Engine Speed	rpm	3:0001	10
Engine P1	Read	500	Engine Percent Load At Current Speed	%	3:0002	10
Engine P1	Read	500	Engine Total Hours of Operation	.05 bit/hr	3:0025 + (32767 *3:0026)	1
Engine P1	Read	500	Misfire	RPM/SEC^2	3:0004	1000
Engine P2	Read	500	Engine Coolant Temperature	C	3:0005	10
Engine P2	Read	500	Keyswitch Battery Potential	Volts	3:0006	10
Engine P2	Read	500	Engine Oil Temperature 1	C	3:0007	10
Engine P2	Read	500	Engine Oil Pressure	kPa	3:0008	100
Bank1 P1	Read	500	Accelerator Pedal Position 1	%	3:0009	10
Bank1 P1	Read	500	Engine Fuel Valve 1 Position	%	3:0010	10
Bank1 P1	Read	500	Engine Intake Manifold #1 Pressure	kPa	3:0011	100
Bank1 P1	Read	500	Engine Intake Manifold 1 Temperature	C	3:0012	10
Bank1 P2	Read	500	Engine Desired Exhaust Oxygen	%	3:0013	10
Bank1 P2	Read	500	Engine Actual Exhaust Oxygen	%	3:0014	10
Bank1 P2	Read	500	Engine Exhaust Gas Oxygen Sensor Fueling Correction	%	3:0015	10
Bank1 P2	Read	500	Manual Bias Bank 1 Total	%	3:0016	10
Bank 2 P1	Read	500	Accelerator Pedal Position 2	%	3:0017	10
Bank 2 P1	Read	500	Engine Fuel Valve 2 Position	%	3:0018	10
Bank 2 P1	Read	500	Engine Intake Manifold #2 Pressure	kPa	3:0019	100
Bank 2 P1	Read	500	Engine Intake Manifold 2 Temperature	C	3:0020	10
Bank 2 P2	Read	500	Engine Desired Exhaust Oxygen 2	%	3:0021	10
Bank 2 P2	Read	500	Engine Actual Exhaust Oxygen 2	%	3:0022	10
Bank 2 P2	Read	500	Long-term Fuel Trim - Bank 2	%	3:0023	10
Bank 2 P2	Read	500	Manual Bias Bank 2 Total	%	3:0024	10

Modbus Alarms

Boolean Read	MSG_	ID_	FMI_ID_	SPN_ID_
1:0001	"AL01 LOSS OF POWER"	111	18	168
1:0002	"SD01 LOSS OF POWER"	112	31	168
1:0003	"AL02 BANK 1 TOO LEAN"	113	15	1119
1:0004	"AL03 BANK 1 TOO RICH"	114	16	1119
1:0005	"AL04 BANK 2 TOO LEAN"	115	15	516099
1:0006	"AL05 BANK 2 TOO RICH"	116	16	516099
1:0007	"AL20 MAP_1 SENSOR VOLTAGE LOW"	117	4	106
1:0008	"SD20 MAP_1 SENSOR VOLTAGE LOW"	118	14	106
1:0009	"AL25 BARO OUT OF RANGE"	119	13	108
1:0010	"AL30 MAP_1 SENSOR VOLTAGE HI"	120	3	106
1:0011	"SD30 MAP_1 SENSOR VOLTAGE HI"	121	31	106
1:0012	"AL40 MAP_2 SENSOR VOLTAGE LOW"	122	4	3562
1:0013	"SD40 MAP_2 SENSOR VOLTAGE LOW"	123	14	3562
1:0014	"AL50 MAP_2 SENSOR VOLTAGE HI"	124	3	3562
1:0015	"SD50 MAP_2 SENSOR VOLTAGE HI"	125	31	3562
1:0016	"AL60 MAP DIFFERENCE OUT OF RANGE"	126	16	516107
1:0017	"SD61 MAP DIFFERENCE OUT OF RANGE"	127	0	516107
1:0018	"AL71 CAM SENSOR FLT"	128	2	723
1:0019	"SD72 CRANK SENSOR FLT"	129	2	190
1:0020	"AL75 MAX CAM TIMING ERROR EXCEEDED"	130	16	723
1:0021	"SD75 MAX CAM TIMING ERROR EXCEEDED"	131	0	723
1:0022	"AL76 CAM/CRK SYNC ERROR"	132	7	723
1:0023	"SD80 ENGINE OVERSPEED"	133	0	190
1:0024	"SD81 ENGINE STALLED"	134	1	190
1:0025	"SD85 KEY OFF"	135	31	1865
1:0026	"AL90 LOAD SENSOR VOLTAGE LO"	136	4	2452
1:0027	"SD90 LOAD SENSOR VOLTAGE LO"	137	14	2452
1:0028	"AL100 LOAD SENSOR VOLTAGE HI"	138	3	2452
1:0029	"SD100 LOAD SENSOR VOLTAGE HI"	139	31	2452
1:0030	"AL111 UEGO 1 SENSE CELL FAILURE"	140	12	724
1:0031	"SD111 UEGO 1 SENSE CELL FAILURE"	141	7	724
1:0032	"AL112 UEGO 1 HEATER VOLTAGE LO"	142	4	724
1:0033	"SD112 UEGO 1 HEATER VOLTAGE LO"	143	14	724
1:0034	"AL113 UEGO 1 SENSOR NOT READY"	144	13	724
1:0035	"SD113 UEGO 1 SENSOR NOT READY"	145	11	724
1:0036	"AL114 UEGO 1 SENSOR FAULT"	146	8	724
1:0037	"SD114 UEGO 1 SENSOR FAULT"	147	2	724
1:0038	"AL115 UEGO 2 SENSE CELL FAILURE"	148	12	516099
1:0039	"SD115 UEGO 2 SENSE CELL FAILURE"	149	7	516099
1:0040	"AL116 UEGO 2 HEATER VOLTAGE LO"	150	4	516099
1:0041	"SD116 UEGO 2 HEATER VOLTAGE LO"	151	14	516099
1:0042	"AL117 UEGO 2 SENSOR NOT READY"	152	13	516099
1:0043	"SD117 UEGO 2 SENSOR NOT READY"	153	11	516099
1:0044	"AL118 UEGO 2 SENSOR FAULT"	154	8	516099
1:0045	"SD118 UEGO 2 SENSOR FAULT"	155	2	516099
1:0046	"AL121 UEGO 1 HEATER VOLTAGE HI"	156	3	724
1:0047	"SD121 UEGO 1 HEATER VOLTAGE HI"	157	31	724
1:0048	"AL122 UEGO 2 HEATER VOLTAGE HI"	158	3	516099
1:0049	"SD122 UEGO 2 HEATER VOLTAGE HI"	159	31	516099
1:0050	"AL123 LAMBDA DIFF OUT OF RANGE AL"	160	16	516106
1:0051	"SD124 LAMBDA DIFF OUT OF RANGE SD"	161	0	516106
1:0052	"AL130 MAT_1 SENSOR VOLTAGE LO"	162	4	105
1:0053	"SD130 MAT_1 SENSOR VOLTAGE LO"	163	14	105
1:0054	"AL140 MAT_1 SENSOR VOLTAGE HI"	164	3	105
1:0055	"SD140 MAT_1 SENSOR VOLTAGE HI"	165	31	105
1:0056	"AL141 MAT_1 TEMPERATURE HI"	166	15	105

1:0057	"SD142 MAT_1 TEMPERATURE HI"	167	0	105
1:0058	"AL143 MAT_1 TEMPERATURE HI DERATE"	168	16	105
1:0059	"AL144 MAT_2 SENSOR VOLTAGE LO"	169	4	1131
1:0060	"SD144 MAT_2 SENSOR VOLTAGE LO"	170	14	1131
1:0061	"AL145 MAT_2 SENSOR VOLTAGE HI"	171	3	1131
1:0062	"SD145 MAT_2 SENSOR VOLTAGE HI"	172	31	1131
1:0063	"AL146 MAT_2 TEMPERATURE HI"	173	15	1131
1:0064	"SD147 MAT_2 TEMPERATURE HIHI"	174	0	1131
1:0065	"AL148 MAT_2 TEMPERATURE HI DERATE"	175	16	1131
1:0066	"AL150 ECT SENSOR VOLTAGE LO"	176	4	110
1:0067	"SD150 ECT SENSOR VOLTAGE LO"	177	14	110
1:0068	"AL151 LUBE OIL PRESSURE VOLTAGE LO"	178	4	100
1:0069	"SD151 LUBE OIL PRESSURE VOLTAGE LO"	179	14	100
1:0070	"AL152 LUBE OIL PRESSURE VOLTAGE HI"	180	3	100
1:0071	"SD152 LUBE OIL PRESSURE VOLTAGE HI"	181	31	100
1:0072	"AL160 ECT SENSOR VOLTAGE HI"	182	3	110
1:0073	"SD160 ECT SENSOR VOLTAGE HI"	183	31	110
1:0074	"AL161 ECT TEMPERATURE HI"	184	15	110
1:0075	"SD162 ECT TEMPERATURE HI"	185	0	110
1:0076	"AL163 ECT TEMPERATURE HI DERATE"	186	16	110
1:0077	"AL190 REMOTE INPUT VOLTAGE LO"	187	4	3938
1:0078	"SD190 REMOTE INPUT VOLTAGE LO"	188	14	3938
1:0079	"AL200 REMOTE INPUT VOLTAGE HI"	189	3	3938
1:0080	"SD200 REMOTE INPUT VOLTAGE HI"	190	31	3938
1:0081	"AL210 TPS1 VOLTAGE LO"	191	4	51
1:0082	"AL211 TPS2 VOLTAGE LO"	192	4	516111
1:0083	"AL212 TPS3 VOLTAGE LO"	193	4	516112
1:0084	"AL213 TPS4 VOLTAGE LO"	194	4	516113
1:0085	"SD210 TPS1 VOLTAGE LO"	195	14	51
1:0086	"SD211 TPS2 VOLTAGE LO"	196	14	516111
1:0087	"SD212 TPS3 VOLTAGE LO"	197	14	516112
1:0088	"SD213 TPS4 VOLTAGE LO"	198	14	516113
1:0089	"AL220 TPS1 VOLTAGE HI"	199	3	51
1:0090	"AL221 TPS2 VOLTAGE HI"	200	3	516111
1:0091	"AL222 TPS3 VOLTAGE HI"	201	3	516112
1:0092	"AL223 TPS4 VOLTAGE HI"	202	3	516113
1:0093	"SD220 TPS1 VOLTAGE HI"	203	31	51
1:0094	"SD221 TPS2 VOLTAGE HI"	204	31	516111
1:0095	"SD222 TPS3 VOLTAGE HI"	205	31	516112
1:0096	"SD223 TPS4 VOLTAGE HI"	206	31	516113
1:0097	"AL230 5 VOLT SUPPLY XDRP_A LO"	207	4	1079
1:0098	"AL240 5 VOLT SUPPLY XDRP_A HI"	208	3	1079
1:0099	"AL250 5 VOLT SUPPLY XDRP_B LO"	209	4	1080
1:0100	"AL260 5 VOLT SUPPLY XDRP_B HI"	210	3	1080
1:0101	"AL261 14 VOLT SUPPLY LO"	211	4	1543
1:0102	"AL262 14 VOLT SUPPLY HI"	212	3	1543
1:0103	"AL270 LAMBDA1 CL CORR > MAX LIM"	213	16	1696
1:0104	"AL275 LAMBDA2 CL CORR > MAX LIM"	214	16	516100
1:0105	"AL280 LAMBDA1 CL CORR < MIN LIM"	215	18	1696
1:0106	"AL285 LAMBDA2 CL CORR < MIN LIM"	216	18	516100
1:0107	"AL290 GQCL > MAX LIMIT"	217	0	1116
1:0108	"AL300 GQCL < MIN LIMIT"	218	1	1116
1:0109	"SD310 CAN1 CONTROLLER ERROR STATUS"	219	2	639
1:0110	"AL311 CAN2 CONTROLLER ERROR STATUS"	220	2	1231
1:0111	"SD320 CAN1 CONTROLLER BUS OFF STATUS"	221	31	639
1:0112	"AL321 CAN2 CONTROLLER BUS OFF STATUS"	222	31	1231
1:0113	"SD330 MAIN SUPPLY VOLTAGE LO"	223	4	168
1:0114	"SD340 MAIN SUPPLY VOLTAGE HI"	224	3	168
1:0115	"AL350 SPEED BIAS VOLTAGE LO"	225	17	3938
1:0116	"AL360 SPEED BIAS VOLTAGE HI"	226	15	3938

1:0117	"AL370 MISFIRE DETECTED"	227	16	1322
1:0118	"SD380 MISFIRE DETECTED"	228	0	1322
1:0119	"AL381 THROTTLE POSITION DIFF"	229	16	516108
1:0120	"SD382 THROTTLE POSITION DIFF"	230	0	516108
1:0121	"AL383 TRIM POSITION DIFF"	231	16	516109
1:0122	"SD384 TRIM POSITION DIFF"	232	0	516109
1:0123	"AL440 ENGINE OVERLOAD (MAX LOAD LIM)"	233	0	92
1:0124	"AL441 ENGINE LOW POWER"	234	1	3464
1:0125	"SD442 UNCONTROLLED OVERPOWER BANK 1"	235	16	3464
1:0126	"AL443 ENGINE LOW POWER BANK 2"	236	1	3465
1:0127	"SD444 UNCONTROLLED OVERPOWER BANK 2"	237	16	3465
1:0128	"SD480 EXTERNAL SHUTDOWN 1 ACTIVE"	238	31	701
1:0129	"SD481 EXTERNAL SHUTDOWN 2 ACTIVE"	239	31	702
1:0130	"SD482 EXTERNAL SHUTDOWN 3 ACTIVE"	240	31	703
1:0131	"SD483 EXTERNAL SHUTDOWN 4 ACTIVE"	241	31	704
1:0132	"AL485 LUBE OIL PRESSURE LO"	242	17	100
1:0133	"SD486 LUBE OIL PRESSURE LO"	243	1	100
1:0134	"AL487 LUBE OIL PRESSURE LO DERATE"	244	18	100
1:0135	"AL490 LUBE OIL LEVEL LO"	245	17	98
1:0136	"SD491 LUBE OIL LEVEL LO"	246	1	98
1:0137	"AL492 LUBE OIL LEVEL LO DERATE"	247	18	98
1:0138	"AL495 COOLANT LEVEL LO"	248	17	111
1:0139	"SD496 COOLANT LEVEL LO"	249	1	111
1:0140	"AL497 COOLANT LEVEL LO DERATE"	250	18	111
1:0141	"AL700 RATEGROUP SLIP"	251	12	629
1:0142	"AL701 PCMHD HIGH TEMPERATURE"	252	0	1136
1:0143	"AL702 PCMHD EEPROM PRIMARY FLT"	253	12	628
1:0144	"AL703 PCMHD EEPROM SECONDARY FLT"	254	7	628
1:0145	"SD800 EASYGEN CAN WATCHDOG TIMEOUT"	255	9	516110
1:0146	"AL801 EASYGEN STOP COMMAND"	256	14	516110
1:0147	"SD920 IC920 CAN WATCHDOG TIMEOUT"	257	9	1292
1:0148	"AL1000 IC920 ERR MISS RING GEAR SIG"	258	8	723
1:0149	"AL1001 IC920 ERR MISS RST SIG"	259	2	637
1:0150	"AL1002 IC920 ERR MISS CAM SIG"	260	2	726
1:0151	"AL1003 IC920 ERR NUM OF GEAR TEETH"	261	13	723
1:0152	"AL1004 IC920 UKN ENGINE APPL CODE"	262	11	1292
1:0153	"AL1005 IC920 OVERSPEED SHUTDOWN"	263	11	1614
1:0154	"AL1006 IC920 EEPROM CHECKSUM ERROR"	264	31	1292
1:0155	"AL1007 IC920 GLOB TIM OUT OF RANGE"	265	19	1436
1:0156	"AL1008 IC920 UKN GLOB TIM OR ENERGY"	266	19	1433
1:0157	"AL1009 IC920 IND TIMING OUT OF RANGE"	267	20	1433
1:0158	"AL1010 IC920 OPEN PRIM RATE EXCEED"	268	0	1292
1:0159	"AL1011 IC920 WAIT FOR 0 SPEED"	269	8	1292
1:0160	"AL1012 IC920 OPEN PRIMARY CHANNEL 1"	270	13	1268
1:0161	"AL1013 IC920 OPEN PRIMARY CHANNEL 2"	271	13	1269
1:0162	"AL1014 IC920 OPEN PRIMARY CHANNEL 3"	272	13	1270
1:0163	"AL1015 IC920 OPEN PRIMARY CHANNEL 4"	273	13	1271
1:0164	"AL1016 IC920 OPEN PRIMARY CHANNEL 5"	274	13	1272
1:0165	"AL1017 IC920 OPEN PRIMARY CHANNEL 6"	275	13	1273
1:0166	"AL1018 IC920 OPEN PRIMARY CHANNEL 7"	276	13	1274
1:0167	"AL1019 IC920 OPEN PRIMARY CHANNEL 8"	277	13	1275
1:0168	"AL1020 IC920 OPEN PRIMARY CHANNEL 9"	278	13	1276
1:0169	"AL1021 IC920 OPEN PRIMARY CHANNEL 10"	279	13	1277
1:0170	"AL1022 IC920 OPEN PRIMARY CHANNEL 11"	280	13	1278
1:0171	"AL1023 IC920 OPEN PRIMARY CHANNEL 12"	281	13	1279
1:0172	"AL1024 IC920 OPEN PRIMARY CHANNEL 13"	282	13	1280
1:0173	"AL1025 IC920 OPEN PRIMARY CHANNEL 14"	283	13	1281
1:0174	"AL1026 IC920 OPEN PRIMARY CHANNEL 15"	284	13	1282
1:0175	"AL1027 IC920 OPEN PRIMARY CHANNEL 16"	285	13	1283
1:0176	"AL1028 IC920 OPEN PRIMARY CHANNEL 17"	286	13	1284

1:0177	"AL1029 IC920 OPEN PRIMARY CHANNEL 18"	287	13	1285
1:0178	"AL1030 IC920 OPEN PRIMARY CHANNEL 19"	288	13	1286
1:0179	"AL1031 IC920 OPEN PRIMARY CHANNEL 20"	289	13	1287
1:0180	"AL1032 IC920 WARN MISS RING GEAR SIG"	290	14	723
1:0181	"AL1033 IC920 WARN MISS RESET SIG"	291	8	637
1:0182	"AL1034 IC920 WARN MISS CAM SIG"	292	8	726
1:0183	"AL1035 IC920 ODD ENGY LVL OUT OF RNG"	293	16	1292
1:0184	"AL1036 IC920 EVEN ENGY LVL OUT OF RNG"	294	20	1292
1:0185	"AL1037 IC920 SCR FAULT ODD"	295	2	1292
1:0186	"AL1038 IC920 SCR FAULT EVEN"	296	2	1293
1:0187	"SD1300 THROTTLE1 GENERAL SHUTDOWN"	297	0	3464
1:0188	"AL1301 THROTTLE1 GENERAL ALARM"	298	15	3464
1:0189	"AL1305 THROTTLE1 POSITION ERROR"	299	13	3464
1:0190	"SD1305 THROTTLE1 POSITION ERROR"	300	2	3464
1:0191	"SD1308 THROTTLE1 WATCHDOG CAN TIMEOUT"	301	7	3464
1:0192	"SD1310 THROTTLE2 GENERAL SHUTDOWN"	302	0	3465
1:0193	"AL1311 THROTTLE2 GENERAL ALARM"	303	15	3465
1:0194	"AL1315 THROTTLE2 POSITION ERROR"	304	13	3465
1:0195	"SD1315 THROTTLE2 POSITION ERROR"	305	2	3465
1:0196	"SD1318 THROTTLE2 WATCHDOG CAN TIMEOUT"	306	7	3465
1:0197	"SD1320 FTV 1 GENERAL SHUTDOWN"	307	0	633
1:0198	"AL1321 FTV 1 GENERAL ALARM"	308	15	633
1:0199	"AL1325 FTV 1 POSITION ERROR"	309	13	633
1:0200	"SD1325 FTV 1 POSITION ERROR"	310	2	633
1:0201	"SD1328 FTV 1 WATCHDOG CAN TIMEOUT"	311	7	633
1:0202	"SD1330 FTV 2 GENERAL SHUTDOWN"	312	0	1244
1:0203	"AL1331 FTV 2 GENERAL ALARM"	313	15	1244
1:0204	"AL1335 FTV 2 POSITION ERROR"	314	13	1244
1:0205	"SD1335 FTV 2 POSITION ERROR"	315	2	1244
1:0206	"SD1338 FTV 2 WATCHDOG CAN TIMEOUT"	316	7	1244
1:0207	"AL1401 CYLINDER 1 OPEN CIRCUIT"	317	5	1268
1:0208	"SD1401 CYLINDER 1 OPEN CIRCUIT"	318	31	1268
1:0209	"AL1402 CYLINDER 2 OPEN CIRCUIT"	319	5	1269
1:0210	"SD1402 CYLINDER 2 OPEN CIRCUIT"	320	31	1269
1:0211	"AL1403 CYLINDER 3 OPEN CIRCUIT"	321	5	1270
1:0212	"SD1403 CYLINDER 3 OPEN CIRCUIT"	322	31	1270
1:0213	"AL1404 CYLINDER 4 OPEN CIRCUIT"	323	5	1271
1:0214	"SD1404 CYLINDER 4 OPEN CIRCUIT"	324	31	1271
1:0215	"AL1405 CYLINDER 5 OPEN CIRCUIT"	325	5	1272
1:0216	"SD1405 CYLINDER 5 OPEN CIRCUIT"	326	31	1272
1:0217	"AL1406 CYLINDER 6 OPEN CIRCUIT"	327	5	1273
1:0218	"SD1406 CYLINDER 6 OPEN CIRCUIT"	328	31	1273
1:0219	"AL1407 CYLINDER 7 OPEN CIRCUIT"	329	5	1274
1:0220	"SD1407 CYLINDER 7 OPEN CIRCUIT"	330	31	1274
1:0221	"AL1408 CYLINDER 8 OPEN CIRCUIT"	331	5	1275
1:0222	"SD1408 CYLINDER 8 OPEN CIRCUIT"	332	31	1275
1:0223	"AL1411 CYLINDER 1 SHORT CIRCUIT"	333	6	1268
1:0224	"SD1411 CYLINDER 1 SHORT CIRCUIT"	334	14	1268
1:0225	"AL1412 CYLINDER 2 SHORT CIRCUIT"	335	6	1269
1:0226	"SD1412 CYLINDER 2 SHORT CIRCUIT"	336	14	1269
1:0227	"AL1413 CYLINDER 3 SHORT CIRCUIT"	337	6	1270
1:0228	"SD1413 CYLINDER 3 SHORT CIRCUIT"	338	14	1270
1:0229	"AL1414 CYLINDER 4 SHORT CIRCUIT"	339	6	1271
1:0230	"SD1414 CYLINDER 4 SHORT CIRCUIT"	340	14	1271
1:0231	"AL1415 CYLINDER 5 SHORT CIRCUIT"	341	6	1272
1:0232	"SD1415 CYLINDER 5 SHORT CIRCUIT"	342	14	1272
1:0233	"AL1416 CYLINDER 6 SHORT CIRCUIT"	343	6	1273
1:0234	"SD1416 CYLINDER 6 SHORT CIRCUIT"	344	14	1273
1:0235	"AL1417 CYLINDER 7 SHORT CIRCUIT"	345	6	1274
1:0236	"SD1417 CYLINDER 7 SHORT CIRCUIT"	346	14	1274

1:0237	"AL1418 CYLINDER 8 SHORT CIRCUIT"	347	6	1275
1:0238	"SD1418 CYLINDER 8 SHORT CIRCUIT"	348	14	1275
1:0239	"SD1430 ALL COILS OPEN CIRCUIT FLT"	349	5	1292
1:0240	"SD1440 ALL COILS SHORT CIRCUIT FLT"	350	6	1292

Declarations

DECLARATION OF CONFORMITY

Manufacturer's Name:	WOODWARD GOVERNOR COMPANY (WGC) Industrial Controls Group
Manufacturer's Address:	1000 E. Drake Rd. Fort Collins, CO, USA, 80525
Model Name(s)/Number(s):	PCM128-HD Industrial 8237-1089 and similar
Conformance to Directive(s):	2004/108/EC COUNCIL DIRECTIVE of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and all applicable amendments.
Applicable Standards:	EN61000-6-2, 2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments EN61000-6-4, 2007: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments

We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).

MANUFACTURER

[signature]
Signature

Suhail Horan
Full Name

Quality Manager
Position

Fort Collins, CO, USA
Place

11/20/2009
Date

5-09-1183 Rev 15, 22-Jan-2009 00292-04-EU-02-01

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